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PRODUCT ENGINEERING

McGRAW-HILL WEEKLY FOR DESIGN ENGINEERS · MAY 1, 1961

WHERE'S PROJECT MERCURY?

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WHICH SHOCK-ABSORBING SYSTEM? . . . page 41
DESIGNING POLYCARBONATE PARTS FOR SHOCK-
NEW RANDOM-ACCESS MEMORIES FOR DIGITAL V
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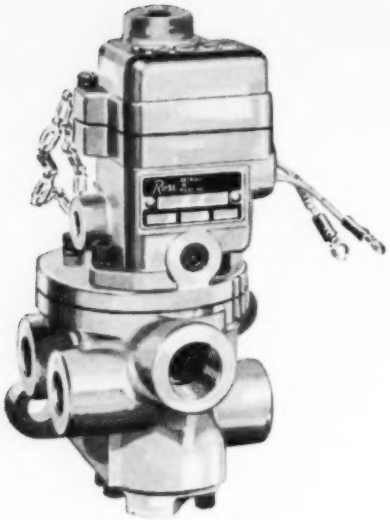

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PRODUCT ENGINEERING

McGRAW-HILL WEEKLY FOR DESIGN ENGINEERS

May 1, 1961 Vol. 32, No. 18

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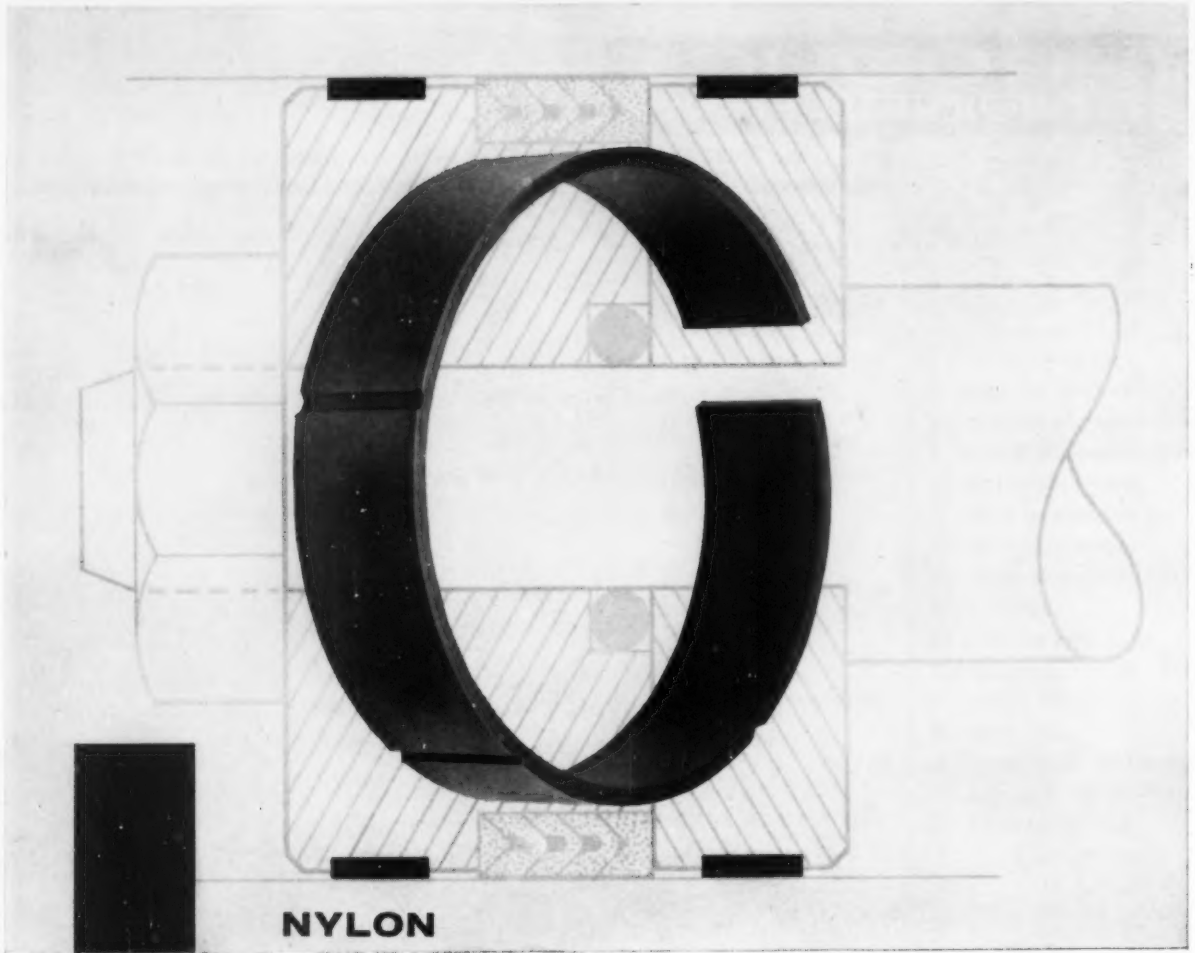

NYLON WEAR RINGS for Hydraulic-Pneumatic Service

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Offer all the fine advantages of Nylon. Garlock Nylon Wear Rings provide satisfactory service in temperatures as high as +350°F. They are unaffected by the normal fluids used in hydraulic cylinders. They exhibit greatly-improved wear qualities and life expectancy. Garlock Nylon Wear Rings are available in a wide range of sizes for new equipment, and will normally fit existing grooves in present equipment. You can order Nylon Wear Rings in nominal diameters (inches) from 2.005/2.010 to 7.005/7.015, and in widths (inches) from .500/.490 to .625/.615, depending on diameters. Special sizes also available.

For more information, call your local Garlock representative. He is at the nearest of the 26 Garlock sales offices and warehouses throughout the U.S. and Canada. Or, write for Catalog AD-179. Garlock Inc., Palmyra, N. Y. **Canadian Div.:** Garlock of Canada Ltd. **Plastics Div.:** United States Gasket Company. **Order from the Garlock 2,000** . . . two thousand different styles of Packings, Gaskets, Seals, Molded and Extruded Rubber, Plastic Products.

As bearings to prevent wear between piston and cylinder (top), Garlock Nylon Wear Rings are gaining fast acceptance among leading manufacturers of hydraulic-pneumatic equipment, such as Hough Loaders (below).

GARLOCK

INTERESTING TO NOTE

Kites—Fast and High-flown Fancy

Designing systems to withstand impact shock presents some interesting problems, as the article on page 41 points out. Shock, whether mechanical or electrical, has always been troublesome to engineers. Ben Franklin got away with it—but when a Russian scientist in the same 18th century attempted to duplicate Franklin's key-on-a-kite experiment, the shock he received was fatal.

Through the years man has used kites to add much to his knowledge of science. Scotsmen sent thermometers aloft on them as early as 1749. More recently, American meteorologists sailed kites 4½ miles above Mount Weather, Va. The pull of the wind was so strong that piano wire was needed instead of string. Radio messages were first sent across the Atlantic in 1894, when Guglielmo Marconi hoisted an antenna on a kite at a receiving station in Newfoundland. Wartime signaling and observation in this century have been carried out with the help of military kites.

On one occasion, at least, kites have powered a land vehicle. George Pocock in 1825 invented a lightweight passenger carriage, towed by two giant kites; it managed to do 25 miles an hour on a straightaway.

Some historians claim that the Greek Archytas of Tarentum invented the kite around 400 BC. But others find evidence that kites were flown even earlier, in New Zealand and Asia. Ancient Egyptian hieroglyphics picture men holding strings that rise heavenward. These might be related to the fable that an Egyptian Pharaoh sent two boys aloft on eagles' backs, with the birds controlled from the ground by strings. In reality, the eagles might have been bird-shaped kites.

Chinese legends are no less fanciful. In one, a farmer and his family returned from kite-flying to find their house destroyed and everything inside crushed.

To express his gratitude to the kite which kept his family out of range of this disaster, the farmer faithfully repeated the exercise on the same day of each succeeding year. His neighbors joined him, and the custom spread. China still observes the 9th day of the 9th month as the "Festival of Ascending on High."

The reason is lost in antiquity, but on Boys' Festival Day in Japan, men who have sons go flying kites. The kites, shaped like fish, each represent a boy in the family. This might have sprung from religious custom, perhaps as a token of gratitude to the gods. Koreans use kites in that way. Prayers are written on the toys and wafted closer to the supposed location of the gods. If there is no wind, the prayers must wait. Some Asiatic kites are decorated with tinkling bells or perforated bamboo shoots. The wind moaning softly through the bamboo is considered by superstitious people to ward off evil spirits.

Practical uses, too, were dreamed up for the kite centuries ago. An oriental general is reputed to have built a bridge by starting with a kite. When the wind was right, he spanned a stream with a sturdy cord on the end of the kite, used it to pull a cable across, and based his bridge on that. Much more recently the same method was used to start the bridge between the US and Canada at

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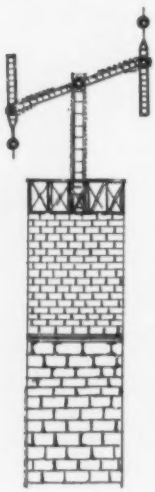
Niagara Falls. A kite carried a lightweight line from one side to the other and construction of the suspension bridge followed.

Readout by Wigwag

Digital readout, subject of the design story on page 55, is certainly not a new concept. In fact, readout devices appear so commonly that we often take them for granted—the cash register, the gasoline pump, the speedometer and the bathroom scale, to mention but a few examples. Transmitting information by "optical devices" goes back even further than the simple digital readout. Indians used reflecting mirrors as well as the familiar smoke signs, Sir Francis Drake conceived an intricate network of bonfires radiating from a hub atop the Dover cliffs—when the Spanish Armada was sighted, fires quickly spread the word throughout England.

During the French revolution, another type of signal came into prominence. In 1790, Claude Chappe allied himself to the new republicanism that was sweeping France. Realizing that communication between the central government and the outlying districts was extremely slow, Chappe developed a system of telegraph towers. Each station was a small house built atop a hill and equipped with a pivoted signal beam that semaphored messages to the next tower in line (sketch at left). By 1794 this network of signal towers was sending messages between Paris and Lille, a distance of 144 miles. The system was so successful that Chappe built more towers between Paris, Strasbourg and Brest. His idea probably would have linked all France had not the electric telegraph been invented.



All told, the Chappe system covered more than 3000 miles and included 556 separate stations—many of them standing today.

America, too, had a visual telegraph based on the semaphore principle. In 1800, Jonathan Grout built a 65-mile line to transmit shipping news between Boston and Martha's Vineyard. —Benedict A Leerburger Jr

SIDELIGHT

Problem: How do you measure the long-term effect of drugs on animals—for example, on their sleep, feeding and drinking, startle reactions, sex patterns, fighting?

Solution: Set a lab assistant in front of the cage with poised ballpoint pen and clipboard.

Now automatic monitoring promises to do the job tirelessly and at considerably lower cost. Stanford Research Inst has a $60,000 grant from the Psychopharmacology Service Center of the US Public Health Service to automate the clipboard. Dr Leon S. Otis heads the group which is developing a "living environment cage" for mice. Here sounds, light, electric shock will be programmed to turn on automatically. The animal's reactions will be measured and recorded for later study.

Under development so far: a *drinkometer* in which the animal drinks from a stainless steel nipple placed between facing, insulated metal plates connected to an 8000-cps signal source. The animal acts as an antenna between the plates, picking up a minute charge and applying it to the nipple as it drinks. A print-out device records time of contact.

A *copulometer* records vibrations of the cage floor picked up by an electromagnetic transducer. It starts a movie camera (for double checking) when the vibrations are violent enough to indicate activity.

NEXT WEEK IN PRODUCT ENGINEERING

. . . **How to Select a Flowmeter**

Up-to-date roundup not only lists the commercially available and distinctive special types—also gives two steps that simplify selection procedure.

. . . **Simple Acceleration Analysis of Low-complexity Mechanisms**

When driven in a certain way, they lose their complexity and become suitable for the analysis method given here.

. . . **Best Heat Treatment for PH Stainless Steels**

When specifying a hardening sequence for semi-austenitic steel, choose the one best suited to your fabrication method.

. . . **Single Nomograph for 18 Constant-strength Beams**

With help of K factor it finds total load the beam will carry, and maximum bending moment.

. . . **How Can Our Patent System Be Improved?**

A patent-holding engineer presents his point of view.

This cylinder for a hydraulic press was cast and machined in a Blaw-Knox Steel Foundry. Weight—231,000 pounds.

Blaw-Knox Steel Foundries have machine capacity to handle the most unusual product requirements

Planing, turning, milling, or boring the most unusually dimensioned casting is no problem in a Blaw-Knox Steel Foundry. There you will find planers up to 15 feet × 15 feet × 36 feet, lathes with an 84 inch swing, and planer type milling machines up to 6 feet × 6 feet × 25 feet. In the same machine shops, you will find the smallest precision tool room equipment.

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Machining to exact specifications with a wide variety of tools is another way Blaw-Knox Steel Casting Service adds value to your product. There is no need to ship the rough casting to another location for machining. You have the advantage of a single responsibility from patternmaking to shipping.

If you design or build a product using cast steel components, ranging from 50 pounds to 300,000 pounds, Blaw-Knox would like you to have a copy of our brochure detailing Blaw-Knox Steel Casting Service. Write to the Foundry and Mill Machinery Division, 300 Sixth Avenue, Pittsburgh 22, Pennsylvania.

BLAW-KNOX

Steel Castings

CIRCLE 5 ON READER SERVICE CARD

WHAT'S HAPPENING IN RESEARCH . . .

More new materials tested for high-temperature lubrication

In the search for dry lubricants that will stand higher temperatures and higher speeds, a host of "unconventional" materials is being tried. Many have failed, but a few now show considerable promise.

Among those tested most recently are lead monoxide, graphite-cadmium oxide mixtures, cerium sulfide, and a group of organic compounds (phthalocyanines) related to vat dye pigments. The first two look very promising; the others not so good.

The vat dye pigments (notably copper phthalocyanine) have proved their ability to raise the temeprature limits of petroleum oils (*PE*—Dec 9 '57, *p* 9). But the outlook for metal-free phthalocyanines as dry lubricants is dim. The compounds do form lubricating film, and bearing surfaces stay clean, but the rate of film formation, at elevated temperature (in the 1200-F range) does not seem high enough to prevent wear. Likewise cerium sulfide seems to offer little or no protection to bearing surfaces.

But preliminary reports on lead monoxide and the cadmium oxide-graphite mixtures are encouraging. Tests at Fairchild Engine and Airplane Corp, using an injection-type lubrication system to supply the compound in powdered form, indicate that cobalt-alloy bearings will operate smoothly at 1200 F on lead monoxide lubricants, with a good protective film forming on all contact surfaces.

Similar tests on cadmium oxide-graphite mixtures also show rapid film buildup on contact surfaces and Fairchild believes this lubricant will function well at bearing speeds of 30,000 rpm in the 1200-F range.

D. S. Wilson of Fairchild is scheduled to present a report on the work at next month's ASME Lubrication Symposium.

Selecting steels for pressurized systems

Molybdenum-vanadium steels (0.12% C, 1.3% Mn, 0.22% Mo, .07 V) give good service in pressure vessels at temperatures to about 800 F, K. J. Irvine and J. D. Murray of United Steel Companies (Britain) report. These steels show less than 0.1% creep strain in 100,000 hr. Above that point, they reported to a special Nuclear Engineering Symposium on the British Iron & Steel Institute, special creep-resisting steels are needed. Aluminum-killed chrome-moly steels (1 to 2.5% Cr, 0.5% Mo) do well in the 800 to 1000-F range and where high strength is the primary consideration, boron-containing bainitic chrome-moly steels of this type have appreciably higher strengths than those with ferrite-pearlite structures.

New route to flexible electrical insulation?

Can insulated high-temperature electrical conductors be "created" by supporting the wires in a series of ball-and-socket annular elements, bonding them together with a ductile material, and then crosslinking the molecules of that ductile material (perhaps by nuclear radiation) to form one gigantic, continuous chemical structure that would provide the necessary flexibility?

The idea may sound fanciful, but John Grebe of Dow thinks it may be done.

And, he says, it may be possible to get around the problems of differential expansion of conductor elements created by higher-temperature operation by radical redesign of the conductor itself—using, perhaps, superductile copper for the inner conductor and thin-wall, corrugated tubing for the sheath, making the corrugations shallow and short-pitched to save space. Tubing of this design is already available (*PE*—Mar 20, *p* 8), and the ductile, gas-free copper tape should not be too difficult to produce. Though these ideas are certainly over the horizon, much progress is already being made in improving high-temperature conductors with new ceramic and conversion coatings and new wire combinations. Some of these materials can stand 1000 F for extended periods, and retain their properties to a high degree.

brief . . .

New semiconductor glossary, this one prepared by Sylvania Electric for a special press briefing, is being made available to PE readers. It's a 4-page mimeographed compendium, which covers about half a hundred key terms, from *absolute maximum ratings* to *varactor*. Address requests to: J. J. Lanigan, Sylvania Electric Products, 730 Third Ave, New York 17.

—ARG

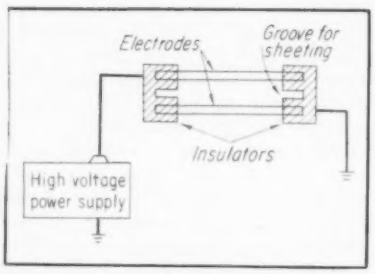
Electrical testing of plastics simplified

An amazingly simple pin-hole detector for TFE plastic sheeting is giving good service at Texaco's Experiment Inc lab.

The device consists of two ¼-in. stainless steel rods mounted one above the other in TFE insulators. The rods serve as electrodes, one being connected to a high-voltage (20,000 v) power supply; while the other is grounded. Grooves in the insulators serve as guides for the sheeting.

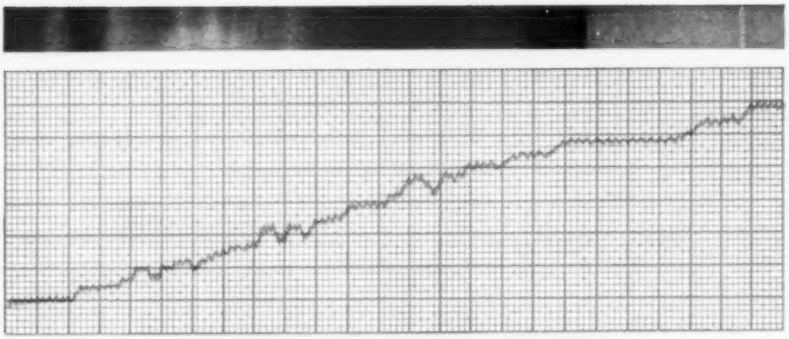
The sheeting is placed in position, the power supply turned on, and the sheet gradually moved past the electrodes. Arcing indicates the presence of a hole.

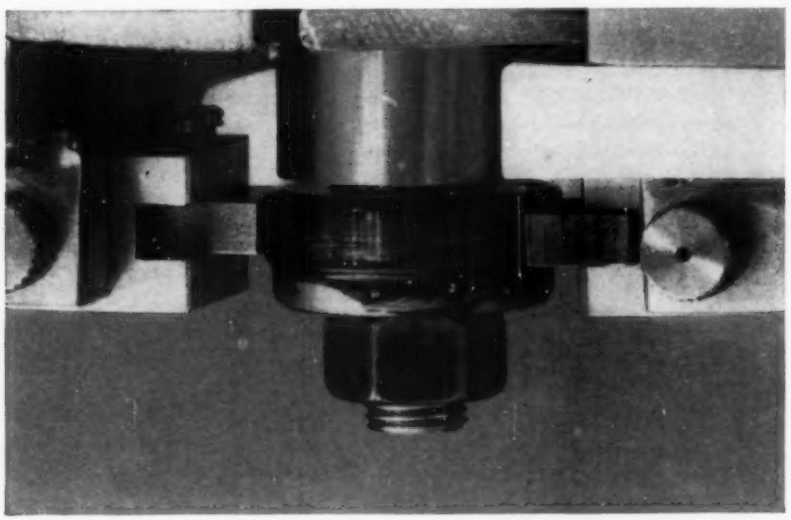
The setup can also be used for dielectric testing, says I. R. King of Texaco, simply by setting the voltage at the desired test point. Areas not capable of withstanding this preset breakdown voltage will be punctured by a spark discharge as they pass between the electrodes.



PIN-HOLE DETECTOR is made by grooving two plastic insulators, inserting electrodes, and passing the sheet to be tested between them.

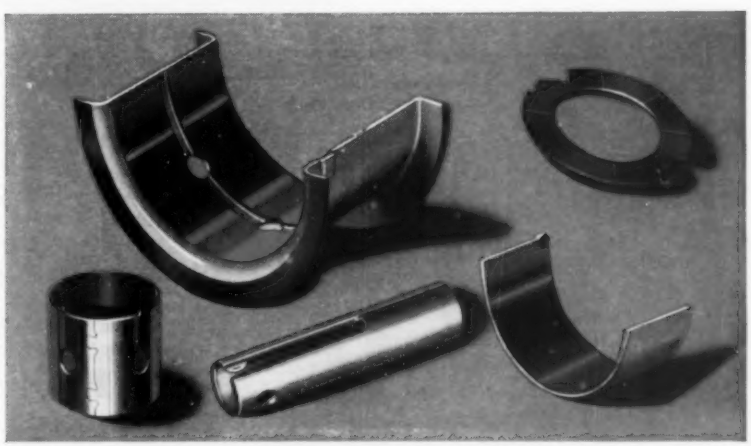
WE TAKE THE PULSE OF BEARINGS ON TAPE TO MAKE THEM EVEN BETTER!





TO TAPE-RECORD THE "HEARTBEAT" OF BEARING METALS UNDER LOAD, WE USE THIS SPECIAL FRICTION AND WEAR TESTER. (left) The result is highly accurate data on the behavior of bearing-metal surfaces, invaluable in our fundamental research into friction. By means of this instrument, we're able to correlate, more closely than ever before, specific alloy compositions with their degree of the "stick-slip" phenomenon (in which one surface sliding over another slides . . . stops . . . slides . . . stops . . . and so on) which accompanies unlubricated sliding action. We can also determine accurately the compatibility of bearing materials with shaft metals in lubricated systems . . . showing us which metal or alloy is most likely to be superior for a given bearing application. In short, this Friction Tester is a fundamental research tool which gives us positive answers to difficult bearing problems, faster than ever before.

ONE REASON WHY F-M SLEEVE BEARINGS and other F-M products give you the finest possible performance — this and the other unusual precision equipment used by Federal-Mogul research. You'll find F-M sleeve bearings used in turbines, engines, and countless other types of power transmission equipment . . . F-M precision thrust washers in pumps, automotive engines and transmissions, motors . . . F-M formed bushings in refrigeration compressors, electric motors . . . and low-cost F-M spacers in motor mounts, machinery, control mechanisms. These are just a few examples.



There's much valuable data in our Design Guides on sleeve bearings, thrust washers, and bushings; and in our brochure on spacers. For your copies, write Federal-Mogul Division, Federal-Mogul-Bower Bearings, Inc., 11043 Shoemaker, Detroit 13, Michigan.

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DEVELOPMENTS TO WATCH...

New materials outperform high-temperature graphite

Pyrolitic materials that promise to be even better in some respects than pyrolitic graphite, itself a major advance over natural graphite as a high-temperature material, are coming out of the lab. First to be announced is a boron-graphite composition now available in developmental quantities from High Temperature Materials Inc.

The new "Boron Pyralloy," says HTM, is 70% stronger at room temperature than pyrolitic graphite and has the highest bend strength above 3500 F of any known material. It will take a fine surface polish, is harder than pyrolitic graphite, shows better oxidation and erosion resistance, and is an even better thermal insulator. It can be made in very large sizes—cylinders to 5 ft long and 2½ ft dia, with walls up to ½ in. thick. Now under test is an even newer material—pyrolitic boron nitride. It will probably be more expensive than the other two, but is expected to offer special advantages (notably, in oxidation resistance) for some applications.

These semiconductors will be the winners

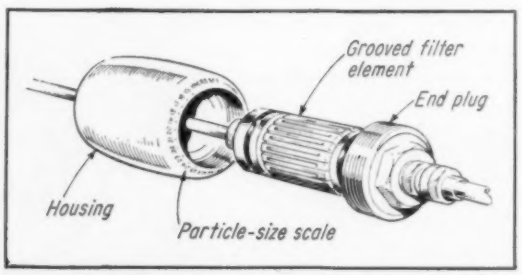
Which of the many semiconductor materials now under discussion will turn out to be industry's work horses? Silicon, germanium, and gallium arsenide, one expert believes. Gallium arsenide, newest of the trio (*PE—Apr 10, p 17*) will be the last general-purpose semiconductor material, Robert Staniforth of Monsanto predicts.

There are many possible semiconducting intermetallic compositions; but none seem able to rival gallium arsenide for all-round use. Some, like indium arsenide, will assume specialty roles. This one has already gone to work in a Hall-effect ac wattmeter that's far superior in many respects to conventional types. Boron phosphide may also offer special advantages—particularly in heat resistance; but all of these pose problems in fabrication or application that may limit their use.

Several of the newer materials are available for evaluation, though. For instance, indium arsenide and indium phosphide, as well as new, float-zone, ultrahigh-purity gallium arsenide, may be obtained from Monsanto on an experimental basis. Requests for information on these should be addressed to R. A. Staniforth, assistant director—Development Inorganic Chemicals Div, Monsanto Chemical Co, 800 North Lindbergh Blvd, St Louis 66, Mo.

Adjustable filter selects particle size

A controlled filtration unit which has a tapered element and housing that can be moved in relation to each other to set the filtration gap to the desired particle size has been designed by I V Pressure Controllers Ltd, Isleworth, Middlesex, England.



EASE OF CLEANING is an added feature of this adjustable filter. To remove collected particles, housing is simply slid back along pipe, as shown.

The longitudinal grooves in the filter element are so arranged that only half are accessible to the fluid as it enters the unit. It must, therefore, escape by passing across the filtration gap to the adjacent groove. In the process, particles are deposited in the grooves, thus achieving the filtering action.

A screw thread controls the adjustment between filter element and housing, and the housing is calibrated directly in microns to select particle size. IVP says the design will handle either liquids or gases, and can be made for working pressures to 6000 psi. Standard filtration range is 6 to 11 microns but ranges from 0 to 5, 5 to 15, and 15 to 25 microns can be produced.

Note: For a major review of filter types and fluids, see *PE—Nov 28 '60, p 29.*

Bimetal shapes to be made by new process

Cast steel shapes that combine two metals—stainless outer layers with low-carbon steel cores, for instance—are being experimentally cast by a new process at American Steel Foundries Laboratories.

The work is still in its early stages; but the company believes an extension of its controlled "Pressure Pouring" technique can do the job. In this process, molten steel is forced by compressed air through a ceramic tube and into semipermanent graphite molds at a controlled rate—producing castings with better surface finish and closer dimensional control than is possible by conventional techniques.

Other developments under test: pressure-poured forging billets with non-directional properties, and welding rod billets.

Soviets using glass film to reinforce plastics

Flexible, ultrathin glass "films" can produce better reinforced plastics, USSR engineers claim. The thin glass sheeting (100 microns or less) is not as strong as fiberglass. But, the Soviets say, "Glass films are superior to glass fibers insofar as their capacity for increasing the mechanical strength of plastics is concerned. Although glass fibers have a high tensile strength, this tensile strength cannot be properly utilized in the production of glass-reinforced plastics because the fibers cannot be arranged uniformly and densely in such a manner that every fiber is subjected to the same load."

Furthermore, they note, use of film in place of fiber makes mechanization of production easier.

A report in the Soviet journal *Ekonomiches-kaya* (1960 #16-688) by Y. Lobtinov claims the biggest problem—large-scale production of ultrathin sheeting—has been licked, and the material is now being readied for commercial use.

Anti-rust paints being developed in Italy

Rust-preventive primers that will not adversely affect paints applied on top of them are promised by a new coating system developed by Monteponi of Italy and now under test in Italy, Britain and the US.

The new system uses zinc cyanamide in place of the conventional zinc oxide and, Monteponi claims, will not accelerate the oxidation and polymerization of drying oils. Some test panels have survived a 100-day salt-mist test, and others were in good condition after 2 years' exposure outdoors. However, Monteponi admits, discrepancies between the two tests indicate the need for further work.

New paperboard resists moisture, gas and solvents

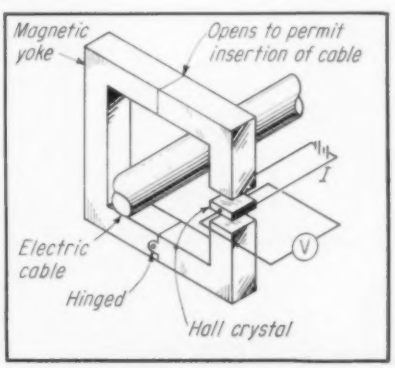
A "high-barrier" paperboard coated with a new PVC emulsion is said to "bring the advantages of Saran-type plastics at modest cost."

Potlatch Forests Inc is introducing it, first as a packaging material; but superior resistance to grease, impermeability to gases, flexibility, and abrasion resistance suggest application as an inexpensive separator and gasket material.

Solid-state dc ammeter being readied for introduction

A Hall-effect dc ammeter that will measure currents to 100 amps—remotely, if desired—is in the prototype stage at Kearfott Div, General Precision Inc, Clifton, NJ. Essentially it is a semiconductor crystal and magnetic yoke (see diagram) which, when clipped around the current-carrying wire, establishes the required field in the crystal. The crystal then develops a voltage, which is proportional to the strength of the field. Kearfott believes it's the only one to combine the advantages of linear reading, high current measurement and clip-on attachment for dc use. A combination ac-dc instrument is now under development.

—ARG

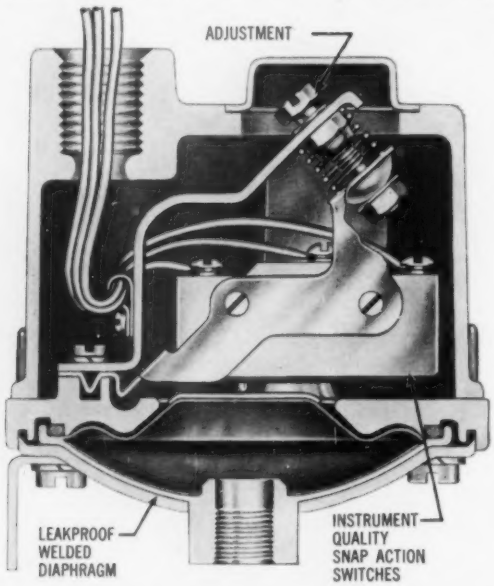


CLIP-ON AMMETER uses Hall effect for current measurement.

BREAKTHROUGH IN PRESSURE SWITCH ACCURACY

at reduced prices

The high accuracy associated with instruments costing several hundred dollars is now obtainable with new Barksdale pressure switches at a retail cost of $19.00 to $30.00. Accuracy of ±0.5% is guaranteed and ±0.2% accuracy can be supplied when required. Substantial price reduction is accomplished by use of erector set design and a major investment in production tooling. A wide choice of "tailored to the job" features (see column at right) meets your specification requirements exactly.



THESE POINTS ARE IMPORTANT

WE BUILD IN	WE DON'T USE
EXTREME ACCURACY and DEPENDABILITY maintained during operating life due to direct acting design	LINKAGES & BEARINGS which, as they wear, make the setting of the pressure switch drift.
OPERATION IN ANY POSITION which saves the installation costs encountered in mounting a switch that uses liquid switching elements	LIQUID SWITCHING ELEMENTS which make the switch difficult to mount and very critical to vibration.
IMMUNITY TO VIBRATION you can mount the switch directly on your vibrating or moving equipment.	ACCORDION BELLOWS which make the pressure switch sensitive to vibration.

PRESSURE SWITCH DIVISION

Barksdale valves

5125 Alcoa Avenue, Los Angeles 58, California

New line of Barksdale pressure switches announced

Improved accuracy, reduced cost and higher proof pressures are advantages made possible by design innovations in the new Barksdale diaphragm pressure switches. Accuracy of ±0.5% as compared to the customary ±1.0% is guaranteed, and each unit is tested for repeat accuracy of set point and re-set point before shipment. Accuracies of ±0.2% are available on request.

Erector set design offers dual benefit

The basic unit of all Barksdale diaphragm pressure switches is a diaphragm surrounded by a heavy protective capsule to which components may be attached as required. Addition of a switch, switch bracket and adjusting bracket to the basic unit makes a stripped switch for use in a common cabinet with other electrical devices. (Original equipment manufacturers need not pay for a housing which is not needed.) Addition of a sealed housing to the stripped switch completes a weather- and vapor-tight switch unit. A standard housing with integral terminal block or an explosion proof housing with integral terminal block may be specified. Erector set construction allows a wide choice in specifications that approximates a custom made switch and permits use of cost-cutting mass production methods that are reflected in lower prices.

Proof pressures to 600 psi

In the low settings the new Barksdale pressure switches will actuate at 0.1" mercury with proof pressure to 10 psi. In higher ranges they will go up to 600 psi proof pressure at settings to 400 psi. This makes it possible to use inexpensive diaphragm pressure switches on installations that presently require higher priced bourdon tube switches.

Important additional advantages

Because the housings of Barksdale pressure switches are independent of the sensing and switching mechanisms changes in ambient temperature will not throw these switches out of adjustment.

The adjustment brackets are specially designed to protect switch terminals against shorting during adjustment.

Lead wires are held down by a tension clip. They cannot be pulled out accidently and thereby throw off the switch adjustment.

Mounting brackets may be oriented in any of four directions.

Tamper proof adjustment covers have servicing instructions on the inside to allow for painting of the units.

Standard pressure connection is ¼" n.p.t. female pipe fitting. One-half inch fittings suitable for mounting directly on ½" pipe can be supplied on request.

Standard housing has ½" nps conduit connections and a terminal block. The latter is accessible without removing the housing by lifting a cover plate.

Ask for new catalog and handbook

Complete details on Barksdale diaphragm, piston and bourdon tube pressure switches are included in a new catalog and handbook. This free book is a practical aid in planning the vital link between your electric and hydraulic circuits. It contains a glossary of terms, a schematic demonstration of operating characteristics, and a suggested step-by-step procedure for simplifying pressure switch selection. In addition, the book gives a complete run-down on all the detail features leading to the unit that answers your specific control problems. Send for your copy now, or ask your Barksdale representative.

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FROM WASHINGTON . . .

Congress prepares investigation of "nonprofit" firms

Nonprofit organizations will soon fall under congressional scrutiny. The House Science and Astronautics Committee, under chairmanship of Overton Brooks (D-La), will hold the hearings.

A key point the legislators will explore is the salaries paid by the organizations. In particular, the committee wants to determine what effect the high salaries paid by nonprofit organizations are having on college and universities in holding their staffs.

Tax exemption and public availability of scientific results of work performed by the "nonprofits" will be aired. The alleged tax abuse by nonprofit groups has long been a sore point in the scientific community.

The congressional committee will also be interested in nonprofit staff members who double as officials of private companies that get subcontracts from the nonprofit organizations.

NASA orders test-firing of 250,000-lb-thrust rocket

A solid-fuel rocket with 3-million-lb thrust may be developed by 1964. With this prospect in mind, National Aeronautics and Space Administration has contracted with United Technology Corp to test-fire its 250,000-lb-thrust rocket by midsummer.

Firing of the 87-in.-dia, 27-ft-long rocket is to demonstrate United's segmented concept of building big solid-fuel rockets. If the tests are successful, it could lead to a contract to develop a 3-million-lb-thrust flight vehicle in the next three to four years.

Total cost for the flight vehicle is estimated at around $200 million. To proceed with the project, however, NASA would need an additional $30 million or so from Congress this year.

The NASA-United contract is one of several solid-fuel concepts the space agency is now exploring. Leading companies in the field are Thiokol Chemical Corp, Aerojet-General, Grand Central Rocket Co, and United Technology.

NASA's solid-fuel rocket program ultimately aims to produce a vehicle in the 15- to 20-million-lb-thrust range for lunar and planetary missions.

AEC pushes R & D of materials

New research program for high-temperature materials has been started by the AEC. Some $6.7 million will be spent on the program in fiscal 1962. Of this, $4.5 million will go to General Electric, $1 million to Pratt & Whitney Div of United Aircraft, and $1.2 million to the Oak Ridge National Lab. Primarily, the research will be directed towards improving materials used in nuclear reactors.

Another $13 million will go to Pratt & Whitney for development of a high-performance reactor experiment. Details on the program are classified.

Air Force-NASA vie over booster choice

A change in the booster for the Air Force-NASA Dyna-Soar manned space-flight vehicle may be forthcoming. Air Force originally planned to use a modified Titan II booster. But NASA wants to use the 1.5-million-lb-thrust S-1 engine cluster that powers the first stage of the big Saturn vehicle.

Its reason, says the space agency, is that this booster will be available before a Titan II can be modified. Hence, first flights of the Dyna-Soar could come by about mid-1963. A final decision on the matter is expected within the next few weeks.

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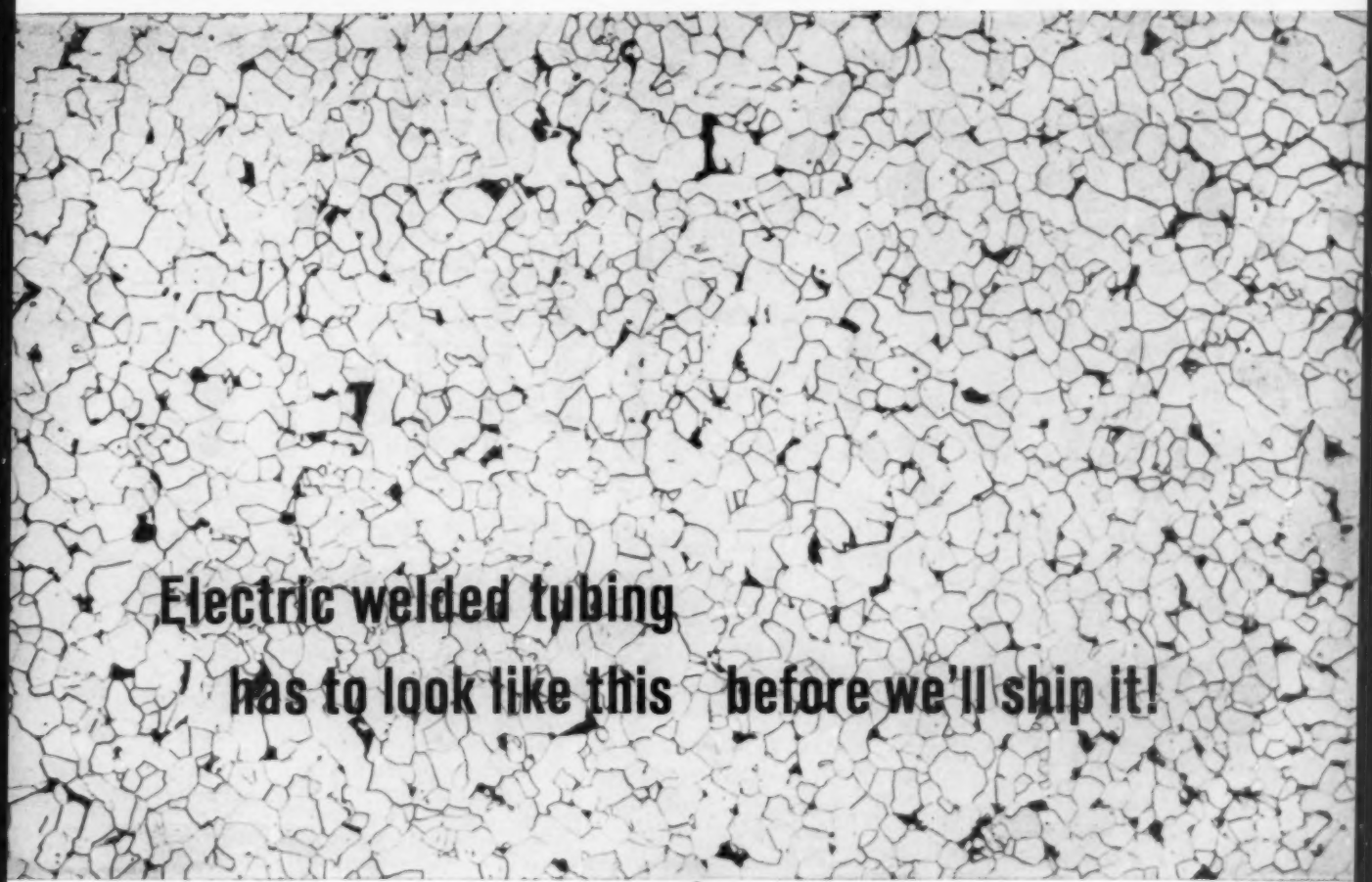

In this photomicrograph of a section of USS National Electric Resistance Welded Steel Mechanical Tubing the weld section runs right down through the center of the picture above the arrow. The consistency of structure between the weld area and the rest of the tube shows that USS National Welded Mechanical Tubing has an important attribute—dependability.

Mechanical tubing must be flawless. It's used in so many critical applications that demand utmost strength, excellent surface inside or outside and extreme dimensional accuracy. National Tube's production methods assure this high quality.

Important advantages of USS National Welded Mechanical Tubing are its ability to reduce machining operations to a minimum or eliminate them entirely. For a given weight, it withstands more load than any other section. It resists bending stresses equally in all directions. In torsion, it provides maximum material distribution.

USS National Welded Mechanical Tubing is available in cold-drawn or hot-rolled sizes ⅜″ thru 5½″ and in wall thickness .035″ to .250″. All sizes can be obtained from National Tube Distributors located throughout the country. They will gladly show how tubing can reduce your costs. *See your USS National Tube Distributor.* *USS and National are registered trademarks*

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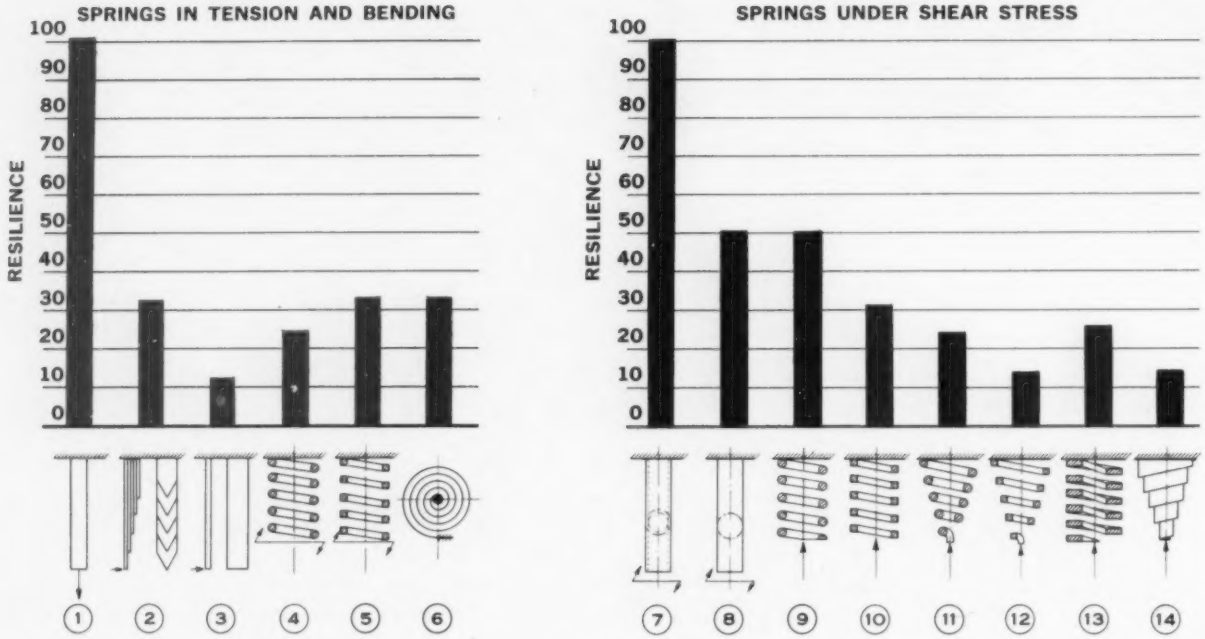
CIRCLE 13 ON READER SERVICE CARD

What Type of Spring to use ?

Here's a quick comparison of relative efficiencies



1. Simple flat spring
2. Leaf spring
3. Rectangular flat spring
4. Round wire compression spring
5. Square wire compression spring
6. Flat wire spiral spring
7. Thin wall tube
8. Solid rod
9. Round wire spring
10. Square wire spring
11. Round wire conical spring
12. Square wire conical spring
13. Rectangular wire spring
14. Volute spring

Relative efficiency of various types of springs can be compared on the basis of energy-absorbing capacity per cubic inch or per pound of metal in the active portion of the spring. For theoretical purposes the simplest forms—wire in tension (1) and thin-wall tube in torsion (7)—represent the ultimate, since all their fibres are stressed alike. The comparisons shown above assume springs are of metal of equal quality, able to withstand the same fibre stress. Obviously, other considerations may affect spring selection such as space available, material desired, atmospheric conditions, manufacturing cost, etc. So efficiency is often tempered by expediency.

If you're embarking on a project requiring springs, tap the knowledge and years of experience available from Associated Spring and its divisions. *Write for "How A.S.C. Solves Design and Production Problems of Springs and Spring-Like Things."*

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THE ENGINEERING WEEK

Where's Project Mercury?

Now that the Soviets have successfully orbited a manned space vehicle it is natural to ask "What's been holding us Americans back from putting a man of our own into space?" The answer, according to McDonnell Aircraft Company and NASA, is the incredible amount of prototype testing and engineering imposed on our Mercury capsule design by the limited thrust capacity of the Atlas ICBM—our primary launch vehicle for the man-in-space program.

NEW YORK—Too little, too late. That sums up America's failure to match Russia's success in orbiting a man around our planet. More specifically, a four-year lead can't be made up in two years, says Dr Hugh Dryden, NASA's deputy administrator. He pointed out to a congressional committee recently that Russia began its space effort in 1954 but our space agency didn't exist until 1958.

And James E. Webb, NASA's new administrator, adds this comment, without amplifying on it: "If there is any bottleneck it's at Cape Canaveral." Probably he was referring to the overloaded facilities at the test center. And this may be the key to our embarrassing lag behind the USSR—despite the fact that Project Mercury carries a top "DX" priority rating and portions of it are on a 7-day-a-week, 24-hour schedule.

Other facts: McDonnell Aircraft Co, St Louis, is general contractor; it was winner of the NASA contract for 12 capsules (now increased to 20) on Jan 12, 1959. On Jan 13, 1960, the first production model was delivered; a second in April, 1960. Currently, 12 of 20 Mercury capsules have been delivered to NASA; only six production capsules have been launched:

- May 9, 1960—Wallops Island test of the escape system was proved by an off-the-pad "abort" (see photo).
- July 29, 1960—An Atlas carried a Mercury capsule downrange for qualification of the two sections and separation tests. Malfunctions at separation aborted the mission.
- Dec 19, 1960—A Redstone booster carried an instrumented Mercury to an altitude of 135 mi and 235 mi downrange from Wallops Island. It proved out the escape rocket at launch, the electrical sequence systems, and the parachute recovery systems.
- Jan 31, 1961—another Redstone pushed a capsule carrying "Ham," the chimpanzee, to 135 mi and 420 downrange. This proved the life-support systems and that man could withstand initial acceleration.
- Feb 21, 1961—an Atlas boosted an instrumented capsule 107 mi high; it reached 13,000 mph and landed 1425 mi from launch. Unlike the July 1960 try, separation succeeded this time. Reentry was proved too—the capsule traveled at speeds far in excess of any planned shot, yet emerged without damage.
- Mar 18, 1961—a Little Joe rocket fired from Wallops Island failed to carry a Mercury into orbit to test an abort sequence at 40,000 ft. This test will have to work before a manned flight is taken.

REDESIGN SOLVES SOME PROBLEMS

Much of the testing has been forced on us by the limited capabilities of the booster—Atlas—selected for the manned-flight sequences. The contract to build the capsules had been based on existing hardware. But when testing and construction got under way, McDonnell found that, to meet the one-ton payload requirement, existing materials would not do and there would have to be drastic miniaturization of existing components as well as of new ones.

- First models of the capsule, for example, had beryllium heat shields. A newly designed fiberglass shield, however, weighs less and does a better job dissipating the high heat of reentry. Such shields—about 6 ft dia—had never been made and required close cooperation between engineering and manufacturing.
- An early test model indicated that on reentry, heat bounce from the bottom of the capsule was charring the René 41 material at the capsule neck. Now the neck is made of beryllium at a cost of $400 per lb after machining.
- Our man-in-space candidates, the "Astronauts," suggested changes after spending hours in the engineering mockup. One change replaced two small portholes with a picture window—measuring only 8 by 11 in. This was enough to upset the delicate

ESCAPE TEST performed at Wallops Island, Va, proved off-the-pad abort sequence could lift capsule about 2600 ft and free of booster. Tower contains rocket package to lift capsule and parachute to float capsule and astronaut to a safe landing.

balance of the capsule on reentry and many engineering manhours were consumed in rebalancing the capsule.

• A major engineering problem was forming the skins of the capsule. Here, two sheets of titanium are covered with a shield of René 41. The large size and extreme thickness—about the thickness of three sheets of paper—had never been welded before.

• Another special design is the space couch that hugs the astronaut during flight. It is made of fiberglass, molded to the contour of the man, and has a special backing of crushable, honeycomb aluminum to absorb the shock of blast-off and landing.

SYSTEM RELIABILITY HIGH

But the most important engineering progress has been the systems researched, designed, constructed and installed in the capsule to make sure the astronaut will survive. Each system has a minimum of one backup and some two or more.

Ground abort: This is under blockhouse control at all times through direct wiring to the capsule, or by radio command after ground wiring has been disconnected. In addition, the astronaut can start an escape maneuver from the pilot control.

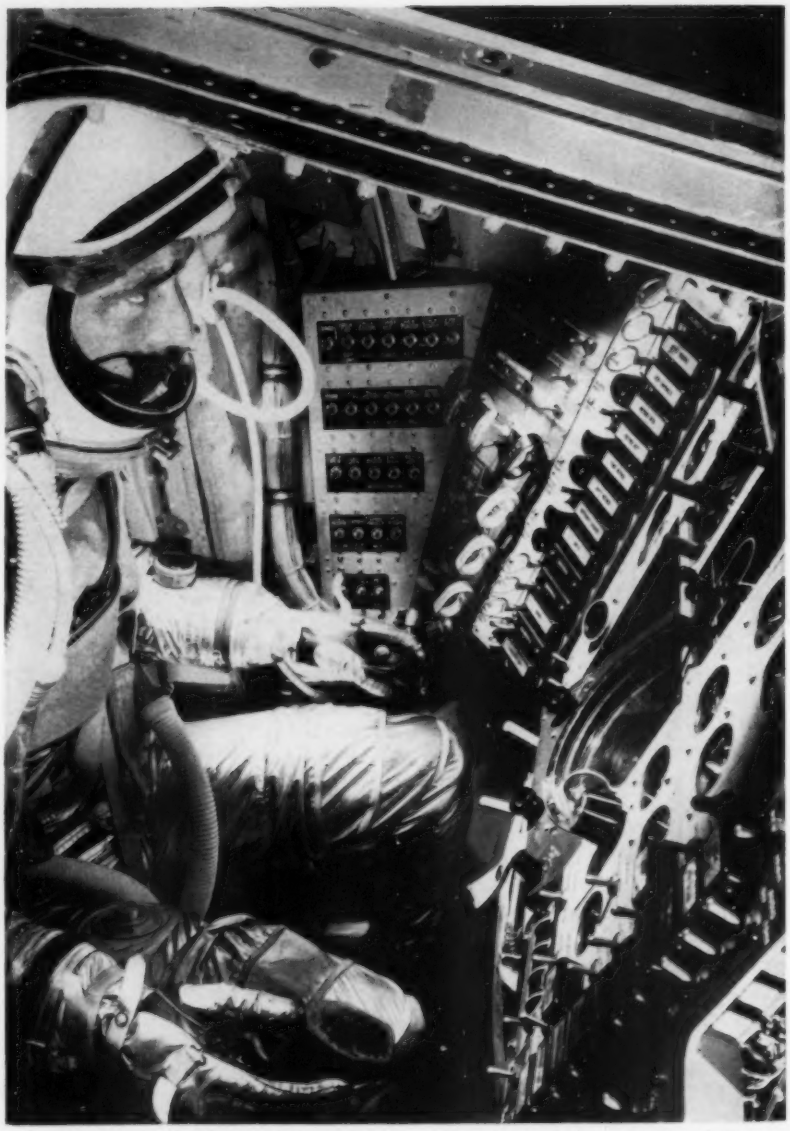
Missile detection: In flight the detection system monitors aerodynamic deviations, possible pending explosions, electric power system failure, thrust failure. As long as all parameters are within design limits, the capsule remains on the booster and continues the launch. Should a booster-component failure occur, the capsule will automatically abort. Ground monotoring can also initiate an abort.

Escape tower: The capsule requires an "engine gone" signal for 20 sec before the escape tower on the top of the capsule can be discarded.

Booster separation: Capsule will not respond to a "cutoff" signal until booster acceleration has dropped to 0.2 g for a period of 2 sec. Three explosive bolts force the booster and capsule apart. Detonation of any one bolt will separate the ring; each bolt is fired from two independent power control systems. In addition, a manual gas-operated percussion-type device will separate booster and capsule.

Reentry: On command, three retrograde rockets fire at 5-sec intervals. Any one of those will slow the capsule to permit safe reentry. Sequence firing gives a control period for the autopilot or manual control system to precisely align the capsule on reentry path. At 40,000 ft, the first drogue chute pops out by means of barometric switches. At 10,000 ft, the main chute opens slowly to bring capsule to a safe landing speed.

Electrical system: Four electrically independent, high-capacity batteries supply correct current through a distribution system to each component; solid-state inverters supply ac to equipment needing it. Two back-up bat-



165 DIALS AND SWITCHES confront astronaut in flight. On far left are emergency switches for all critical-systems operations. T-shape handles to right of emergency panel depressurize (left) and repressurize (right) the cabin. Top big ring (easier to grasp with gloves) sets controls for automatic or manual flight. Roll, yaw and pitch handles, directly below, are used in conjunction with control stick in astronaut's right hand during manual flight. Third section contains sequence lights which indicate (top to bottom) the functioning of all capsule systems during flight on a time sequence. Manual backup switches are to left of lights. Top of center panel contains orbital timing device, 24-hr Greenwich-time clock, earth-path indicator and periscope. Left section of center panel has gravity instruments, fuel gages, descent and attitude indicators, and other flight instruments. Top right are environmental-condition instruments, electrical control panel, and radio system. Panel at extreme right has warning lights and audible warning signals. Astronaut holds launch abort control in left hand.

teries are supplied in event of failure or primary battery exhaustion. One battery will switch on automatically so mission can continue for at least one additional orbit. Other battery can be switched on manually in case of complete failure.

Stabilization system: The control forces to hold or change capsule position in space are provided by hydrogen peroxide system. These are controlled by two independent sources: one, by the autopilot, is programmed to give control throughout the entire mission; the other, by manual operation. In event of autopilot failure, electrical interconnects give control to the astronaut through the control stick in his right hand (see photo).

Environmental control: Designed to provide life-support conditions to the astronaut, it also gives 5-psi pressure at 70 to 100 F for the electronic equipment in the cabin. This system supplies the capsule pressure shell, a closed-loop circuit for the man's suit, and an emergency circuit loop. Some 10 other back-ups are provided—both automatic and manual—including a system to eliminate oxygen in the cabin in case of cabin fire.

All of these and several other systems required extensive testing and occasional redesign. McDonnell used "pyramid testing," that is, each component tested individually and then tested again at each assembly.

SYSTEM-ENGINEERING PROBLEMS

Although ground testing might show perfect operation the Space Task Group at NASA's Langley Research Center checked each system for foolproof operation at minimum weight under actual flight conditions. Here are some engineering problems encountered on the various systems:

Escape: Shortly after launch, at approximately 38,000 ft, severe lateral pressures on the missile, in the order of 1000 psi, are encountered. To save the astronaut and capsule under this "worst condition," a system of JATO bottles has been designed atop an escape tower (see cover). To escape, the astronaut signals the release of a strap-clamp holding capsule to missile. This release then trips limit switches which, in turn, fires the escape rockets.

Problem: In two tests at Navy's Wallops Island test facility, using low-cost solid-fueled Little Joe rockets, the proper sequence of events in this separation mechanism has not been achieved: in one of the Little Joe series, separation never occurred and the missile and capsule crashed into the ocean intact; in the second test, the clamping system freed properly but not in time with the escape rockets, which fired prematurely.

Solution: The basic cause has not yet been isolated, and tests continue although manual operation, it is believed, would have freed capsule.

Life support: Design provides more than simply a survival environment; it gives one in which the astronaut can carefully observe his reactions and exercise his judgment on operation of the vehicle (the main reason, says NASA, for sending a human instead of his weight in instruments).

Problem: How to supply sufficient oxygen for the entire trip in a container of minimum weight without getting into the complexities of a liquid-oxygen converter that would have to sustain all manner of g-loading.

Solution: After trial of many materials, an all-metal spherical gas bottle slightly smaller than a basketball was designed to contain sufficient oxygen at 3500 psi to sustain the astronaut, but weigh (empty) less than 5 lb.

Control: Deviations in attitude are sensed by infrared devices which, in turn, signal trimming jets.

Problem: What kind of jet system will be lightweight, reliable, and delicately controlled to avoid over-correction?

Solution: A system of jets ejecting steam formed by trickling hydrogen peroxide over silver nitrate screens. Signal from the infrared sensors activates internal valves that release controlled amounts of peroxide; once correct steam pressure is obtained, external valves open to emit the correcting jet of steam.

The control system must also be able to initiate descent from orbit upon ground command.

Problem: Even though all components of the command system operate as designed on the ground, how do you learn whether the system will be absolutely reliable in actual flight?

Solution: This requires a series of tests. Already tried is the down-range flight of the capsule. Still to be run is a sub-orbital test in which the capsule comes within about 100 ft/sec of orbital velocity—then is aborted from its mission.

Landing: To cushion the final landing, the capsule is equipped with an inflatable landing-impact bag stowed beneath the heat shield. For a water landing which is planned, the impact bag deflates, fills with water, and forms a sea anchor.

Problem: In the first test with the Redstone missile as vehicle impact drove a protruding external bolt on the heat shield into the lower pressure bulkhead, allowing a foot or so of sea water to enter the capsule.

Solution: Redesign, with continuation of drop tests from jigs, helicopters, and along slanted ways to simulate angular impact. And a filling of slow-crushing aluminum honeycomb, with a glass-reinforced plastic sheet was incorporated between shield and bulkhead.

Problem: In the second test, wave action tore the heat shield away from the impact bag.

Solution: Special flotation tests in artificial-wave tanks to find the best way to reinforce bag and shield.

MIRACLE OF THE PROGRAM

Despite the short lead-time, the many tests, the engineering changes and minor problems still to be solved, Project Mercury is a "going concern." The slow, but steady pace should guarantee a safe and accurate man-in-space shot—as well as continued shots that will give us the scientific knowledge and engineering know-how to leave the orbit of our own earth. The miracle of the program is not the development of the systems and the back-up to them, but that in two years a capsule has been designed and constructed.

—Ford Park, Associate Editor
—T Schafers, St. Louis Bureau

CIRCLE 18 ON READER SERVICE CARD →

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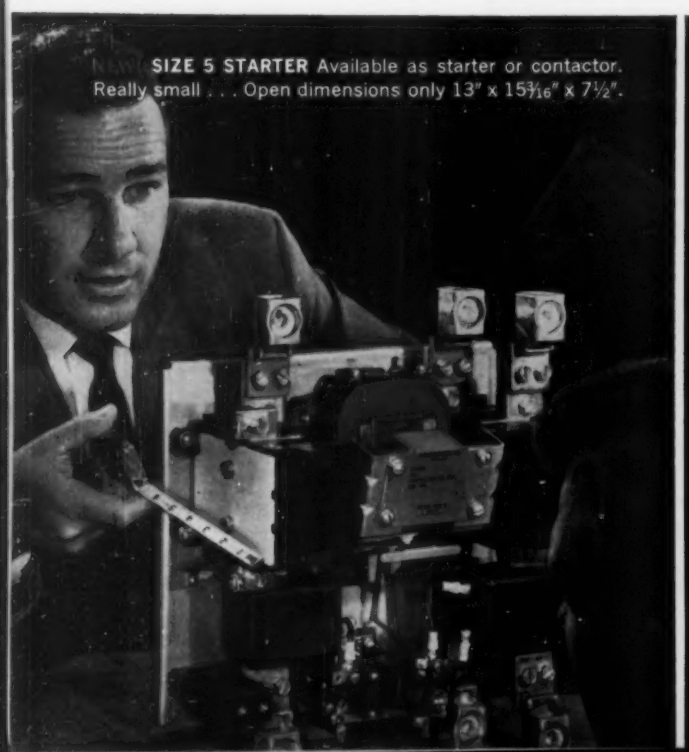

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MOST VERSATILE FOOT SWITCH YET Choice of 4 operating variations by changing nylon cam position.

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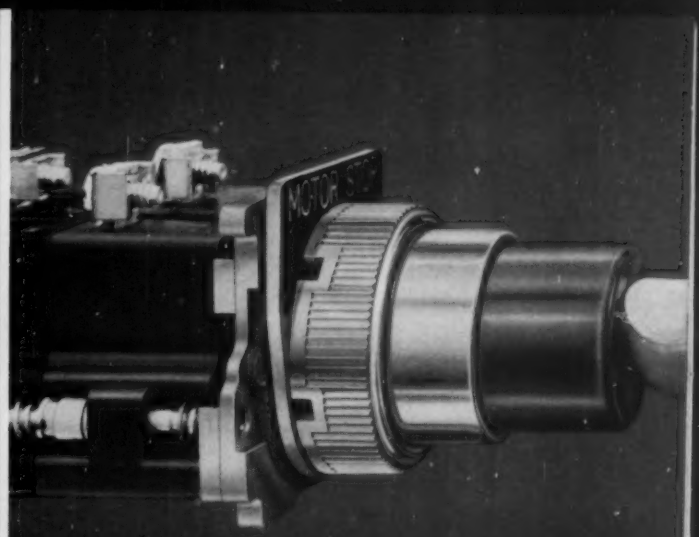

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WHAT'S NEW? ASK...

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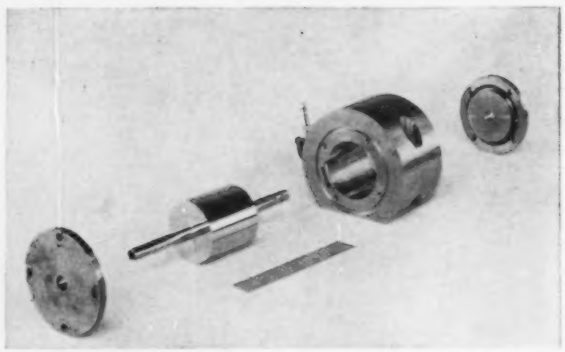
CONTROL

SPACE-SAVING 00 STARTER Takes 20% less space, costs 18% less than Size 0.

MOST RELIABLE LIMIT SWITCH EVER This oiltight switch outlasts others by far. Many operator options.

HYDROSTATIC BEARING—compressed air is admitted through the shaft and passes into the sphere made, in part, of a porous material. Escaping air forms a continuous lubricating film between sphere and wheel hub. Some air escapes through the drilled tangential ports in hub to impart rotation to the wheel.



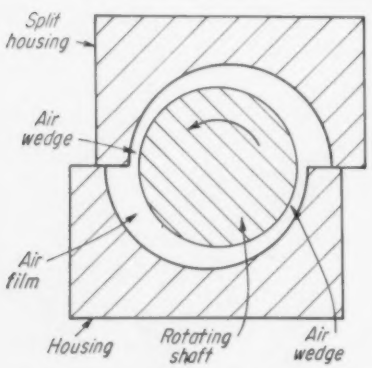
IN HYBRID BEARING, externally compressed air is admitted through porous insert shown on inside of the journal. This air lifts the rotor free of the journal until a minimum speed is reached—then external air is cut off and bearing becomes self-pressurized. Compressed air must be turned on again before the rotor is stopped.

Air-lubricated Bearings Heading for War and Space Applications

DETROIT — Two basic types of air-lubricated bearings have been developed at the experimental labs of Chrysler's Missile Div and, according to the company's engineers, can now be produced economically. The bearings are expected to have broad applications in military and space vehicles.

One is a hydrostatic type—based on an externally pressurized design (for developmental report on working model, see *PE—June 6 '60, p 21*). The air or other gas is admitted, under pressure, through a porous material to the space between shaft and bearing. This porous material is a sintered metal, containing voids which account for 15 to 50% of its volume. The material is designed into either the bearing shaft or journal, depending upon which element is stationary.

The other bearing is a self-pressurized (hydrodynamic) type. Here, rotation of the shaft creates the pressurized air wedges that hold the shaft free from the journal. The journal is a special offset-semicircle configuration. Usually, a minimum speed of 500 to 1000 rpm is necessary to eliminate metal-to-metal contact. Chrysler reports that load-bearing capacity of the hydrodynamic unit increases with speed up to 60,000 rpm—the maximum at which it has been tested. However, this type is generally limited to lower loads per unit of projected bearing surface than is true of its externally pressurized counterparts. Development work on this concept has been sponsored by the Wright Air Development Div of the ARDC.



SELF-PRESSURIZED BEARING— Chrysler's version is based on an offset semicircle design.

Chrysler also reports success in testing a third unit, which combines inherent advantages of the two basic types. In this hybrid, at zero velocity, the shaft is held free of the journal by externally pressurized air. But once minimum speed is reached, the assembly operates as a self-pressurized bearing (additional design information, see *PE—Apr 10, p 56 and May 15*).

Gas bearings are expected to have applications in environments for which liquid or solid-film types will be inapplicable, even assuming their continued improvement. Liquid bearings have limitations because viscosity of the lubricants decreases with temperature and the liquids are easily contaminated. Solid-film lubricants, though free of these shortcomings, are apt to deteriorate chemically. And wear is a problem because of metal-to-metal contact between bearing surfaces.

In gas bearings, viscosity increases only slightly as the temperature rises. This change is nearly linear. Usually, ambient air can be used for the lubricant, but in cases where it is unsuitable, other gases will do, generally with a recirculating system. Almost any combination of properties can be found in existing gases or tailored from a combination of gases. Sometimes exhaust gas can serve as lubricating medium; and in some designs, this lubricant can be put to work as bearing coolant or a source of usable power.

—Felix Giordano, Regional Editor

Give Us Better Technical Communications, Engineers Ask

NEW YORK—Engineers are not entirely satisfied with the flow of technical information across their desks. This analysis by Deutsch and Shea, Manpower Communications Consultants, resulted from interviews with 131 engineers, followed by questionnaires to 106 others. The survey showed fewer than 60% of engineers find the flow of technical information is good enough. And many who do, complain that they lack time to absorb the necessary information.

As one put it: "There is enough information, all right—the trouble is not enough time to digest it. The technical information should be more condensed, more to the point, brought

down to its barest minimum for the transmittal of the necessary intelligence. Or we must invent a way of learning faster."

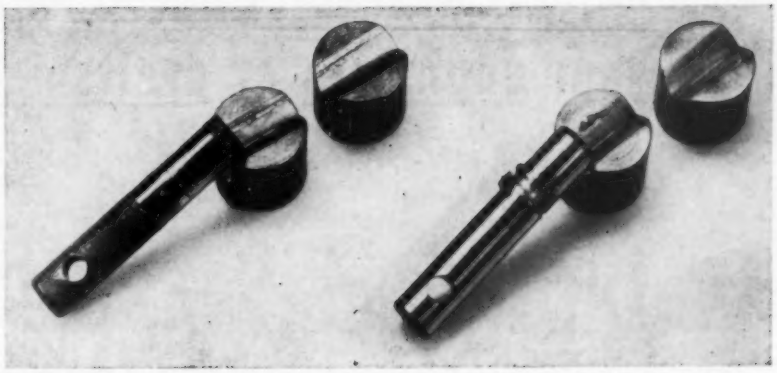
The survey found that engineers tend to rely most on contacts with fellow professionals for information; they also depend on technical journals, though the periodicals are sometimes criticized on grounds of timeliness.

The engineers offered many suggestions for improvement. These included improved library services; allocation by management of more time for reading technical journals; coordination of projects through formalized contacts across interdisciplinary lines (i.e., physicists with electronics engineers; chemists with process engineers); and more direct communication with university and outside professionals working on similar projects. In addition, the technical men asked for improvement of magazines and reports through abstracts and summaries in the front of each issue and for creation of an industry-wide clearing house service to keep each engineer informed of technical literature and papers in his field.

On the question of over-all satisfaction with jobs, Deutsch & Shea found that one engineer in four is discontented, against 17% who are well satisfied. About 45% of the remainder are fairly well content. Even the dissatisfied were reported generally reluctant to change jobs now.

The reason for this was attributed in part to psychological factors, in part to finances. Engineers are said to be stable by nature, so will try doggedly to improve a situation before deciding to leave a company. Also, many tend to be introverted; the prospect of new surroundings and personalities is uninviting. Financially, the mobile engineer loses benefits from pensions and annuities. And many have family responsibilities which limit job-hopping.

Even so, more than 80% of the technical men queried said engineers can improve their lot by moving, despite the standardization of salaries and benefits in much of industry today. Those who had changed jobs were believed to rank higher on the pay scale; also, change is seen as a way to broaden viewpoints and learn about other methods, procedures and technical fields that may be of greater interest. ■



Tufftrided pin, left, is still intact though subjected to more abusive test than its untreated companion. Treated pin was rotated between the steel jaws at 290 rpm for 55 sec with an applied load of 1450 lb. Untreated pin was rotated at 290 rpm under 350-lb load for 4 sec—when damage became severe. Both pins are SAE 3135 steel; jaws, ASIS-C-1137 steel. Tufftrided pin was treated at 1050 F for 90 min., then water-quenched. Jaws were not treated.

German Chemical Process Imparts Durability to Steel Items

DETROIT—Steel products with greater wear resistance and toughness are promised by a new heat-treating process developed in West Germany and now available in this country through the Kolene Corp. It has an exclusive license for North America.

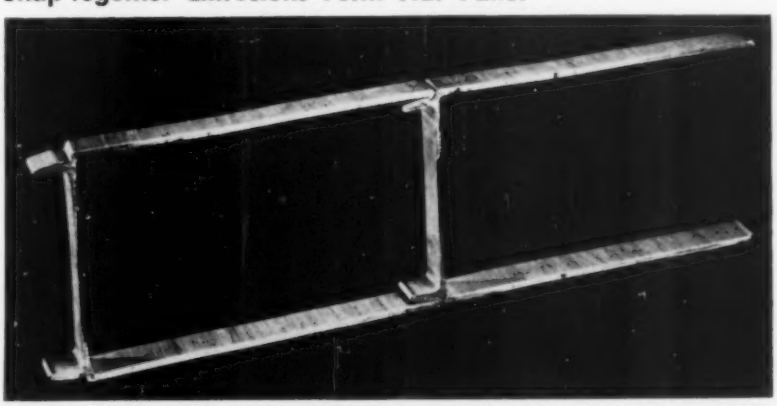
Known as Tufftriding, the process employs nitrogen as its active agent, but is said to differ from standard nitriding processes both in method of application and in characteristics imparted to the treated parts. Kolene engineers say it increases corrosion resistance of non-stainless steels, also giving them higher rolling-fatigue limits and higher fatigue strength. In addition, the treated steels are more immune to galling and cracking.

The process is said especially helpful for improving wear of parts whose lubrication is difficult or impossible, and it points the way to substantial cost reduction—Kolene engineers say they were able to substitute Tufftrided 1045 steel for 4137 steel.

The process is chemical—it impregnates carbon or alloy steels and cast iron with a controlled concentration of nitrogen in a low-temperature (1050 F) molten salt bath. This takes less time than nitriding, thereby minimizing chances for distortion.

—Felix Giordano, Regional Editor

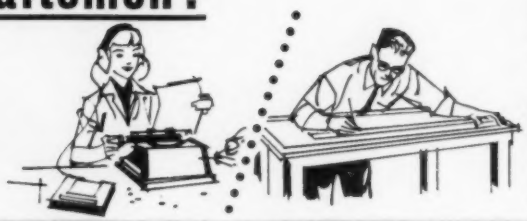
Snap-together Extrusions Form Flat Panel



A ladder-like assembly of extruded aluminum has been developed by Reynolds Metals Co to replace corrugated sheet in areas where double-wall action is required. Sections snap together by spring action. Shape was designed primarily for railroad freight car ends but may find application for machinery mounts and other areas of high vibration. An insulating material could be placed between the skins. Advantages claimed are better strength-to-weight ratio, ease of fabrication, and lower cost.

Is your secretary better equipped than your engineers or draftsmen?

She deserves the best, bless her, and often gets it—but your skilled *draftsmen*, too, need today's tools to cope with today's demands.



Your draftsmen, your productivity, deserve new Hamilton space-and-time-saving equipment—from Bruning

Even your most efficient and productive men turn out better work with high-quality, professionally designed drafting equipment. They will accomplish more, make fewer errors and be far less fatigued when they work with Hamilton professional equipment. Basic Hamilton design gives your engineers or draftsmen new capacity for increased efficiency and improved morale. Our designers will help plan your individual needs.

HAMILTON DELUXE AUTO-SHIFT TABLE This unit combines modern styling with advanced features to create top efficiency. It greatly reduces fatigue, helps your men achieve the highest quality in draftsmanship and maximum production. Fully seasoned drawing surface is adjustable to individual height and slope requirements, providing complete board accessibility that reduces errors. Fast, simple adjustments. Unusually durable and handsome in appearance.

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Hamilton L-Contour Table
Prestige-assured, individualized work area providing complete board adjustment plus extra storage and reference area.

Hamilton CL 100 Drafting Table
Conserves dollars, yet rugged canted-leg design provides modern styling and convenience with long-term durability.

Put draftsmen in a "position" to do better, faster work!

Bruning's all-new Neoglide drafters literally help draftsmen straighten up and do faster, better work.* They provide complete maneuverability on any board at any angle without adjustment! Reinforced U-beam construction assures rigidity, strength, and accuracy. Resistance-free movement of vertical beam and hidden counterweight provide fast "floating" action.

Touch-control protractor head gives automatic, pinpoint angle selection.

*Study of 300 draftsmen showed 35% savings in drawing time—1/5 the backaches—on vertical or near vertical boards.

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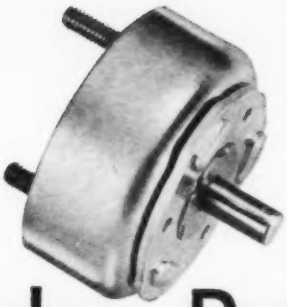
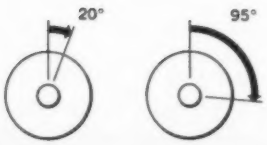


Ledex Rotary Solenoid

BASIC INFORMATION



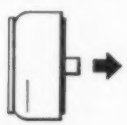
Standard Ledex rotary Solenoids will provide rotary strokes from 20° to 95°.

Action is snap-type, with spring return to starting position after completing stroke.

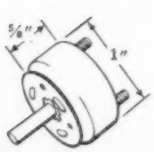
Action is instantaneous, approx. 1/30 sec. for 35° stroke and return.

Available in left hand stroke as well as right.

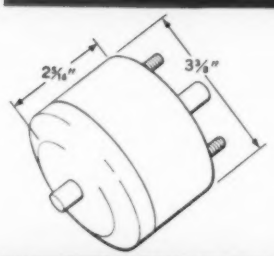
Standard Rotary Solenoids provide torque almost equal throughout stroke. Higher starting torque models can be designed.



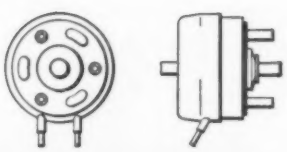
Will also provide powerful, highly efficient, short stroke piston action.



Smallest is size 1E, same weight 1½ oz., torque up to .8 pound inches.



Largest is size 8S, same weight 4 lbs. 3 oz., torque up to 99 pound inches.



Standard power take-offs include armature plate with three tapped holes and shaft extension from either or both ends. Special designs available.

The Ledex Method of actuation and control gives instantaneous high-torque-to-size rotary motion and high-thrust-to-size piston motion, for reliable remote mechanical actuation or remote control of rotary-type switches.

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High-thrust-to-size piston motion

Other Ledex Method products are Syncramental Stepping Motors, Rotary Stepping and Selecting Switches. Write for Bulletin A-1259, mentioning application, to Ledex Inc., Dayton 2, Ohio; Marsland Engineering, Ltd., Kitchener, Ont.; NSF Ltd., 31 Alfred Place, London, Eng.

CIRCLE 23 ON READER SERVICE CARD 23

POINTS OF VIEW

THE QUESTION: *Is Engineering the Sole Source for*

Can committees design effectively? What's the industrial designer's function in product planning? To discuss these questions, Product Engineering *invited Don Dailey to present his point of view.*

I do not believe so. Any "sole source" of product ideas would be a limited source and no company can afford a limited scope of product ideas. A good engineer is circumspect by nature and training. As such he is neither the sole source nor necessarily the best source of product ideas. Nevertheless, the engineer has the potential of being the key factor in intelligent stimulation of ideas. The fact that he has sometimes lost control of this function arises partly from assumptions that he was the "sole source." Obviously, not all ideas stem from engineers, nor do all engineers have ideas. Ideas imply creativity, and creativity should not necessarily be the main characteristic of all engineers.

Today's competitive market requires a constant flow of new products. When competition was less acute it was sufficient that product ideas stemmed from the engineering department alone, with only an occasional contribution or prod from the sales department or management. But now many industrial leaders have established targets whereby substantial percentages of annual gross revenue must come from basically new products (not redesigned ones). Meeting these goals requires a new concept of planning. A few years ago new products and product-improvement ideas came about in haphazard ways—unscheduled and unplanned—and the little that was deliberately planned was prompted by the influence of competition. But today's faster moving and more active competition, plus generally longer and more thorough development procedures, combine to make it imperative to have planned programs that operate in advance of competitive need.

DON DAILEY, ASID

Nationally active in the field of industrial design for 20 years, Don Dailey was among the first 20 to join the American Society of Industrial Designers, is a member of its board of directors, and is chairman of the committee rewriting its Code of Practice. Dailey won the IDI Award for Most Outstanding Product Design of the Year (1953), Design in Hardwoods Annual Award (1958), PRODUCT ENGINEERING's Master Design Award (1959), and the Western Electric Show and Conference Award of Merit (1960).

Organizational charts don't produce

The engineer's unwillingness to "tool up" for broader and more virile idea production has frequently resulted in the responsibility's being delegated to marketing or product-planning groups. But this rush to "planned planning" has resulted in many amateurish and ill-fated attempts. Some of these efforts look fine on paper or organizational charts, but fail to produce. The reasons are several:

- Excessive reliance on the organizational chart
- Overemphasis of titles and job description
- Ignorance of the creative process
- Inherent limitations of committee action
- Elimination of the human element of personal incentive
- "Catching-up-with-competition" planning
- Occasional overemphasis of marketing as the key to all product planning.

Many of these have resulted from the fact that "planned planning" is a relatively new element in industry, and not fully comprehended by management or management engineers. They have recognized the need without realizing the procedures. This lack of awareness of the functional factors of idea generation and development has produced false confidence and subsequent rude awakenings. The current popularity of the magic word "marketing" has produced attitudes (and sometimes mandates) that no creative thinking should be done until a need was defined by marketing. Although logical in theory, this attitude ignores several realities known to engineers and designers as essential to successful creative and developmental procedures.

Basically, the engineer's tendency is to settle on one concept and "prematurely" proceed with its development. The marketing-minded person on the other hand, is generally unaware of technical time factors. He fundamentally

does not understand why product- or package-development cannot occur as rapidly as the advertising, publicity, display, and printing production with which he is most familiar. But there is a third attitude that also becomes a barrier to the planned generation of product ideas. This is a characteristic shared by both engineer and marketing man—the tendency to be unduly influenced by competitors' successes and to imitate rather than create.

Committee design—only as good as head man

These attitudes hamper sound idea planning. To avoid these influences, new-product committees have been formed to include counter-characteristics. But, unfortunately, committees are not inherently creative and, being made up of a number of divergent specialists, tend to bog down in matters of communication and parliamentary procedure. Their success will generally be in relation to the ability of the individual who sparks or heads the committee. Even successfully functioning committees fail to produce successful results. The procedures and people can be right but the results lack virility, sensitivity, impact, and proper timing. The most successful programs I have observed or participated in are those where one individual possessed sufficient personality and influence to weld the various attitudes into a synchronized result. This individual could be an engineer, marketing man, industrial designer, or top executive. His label is less important than his sensitivity to the over-all picture and his dedication to the challenge of ideas and people. This person has a better chance of coordinating the various talents and departments if he does not officially represent any one departmental activity.

Age of specialization

We now have specialization within specialization—and yet we still have problems of keeping abreast and planning for a future where both the demand for knowledge and the demands for application of ideas will be many times greater. No longer will we be able to say "engineer" or "electronics engineer"; we will have to define the exact area of electronics in which the person is qualified and active. This new superspecialization is not just a matter of the subject of endeavor, but also the aptitudes of the endeavorer. For instance, my profession of industrial design has become so complex that it is necessary to determine whether a given industrial designer is best as idea man, stylist, or technical developer. Each bears the label "industrial designer" but we shall have to be more specific.

The man with an idea may not be qualified to develop the idea. Likewise a person with the training and aptitudes to develop ideas might be so subjective by nature, training, and attitudes as to be almost devoid of the objectivity and flexibility necessary to conceive ideas. The science of individual aptitudes must be applied to the problem of product-idea generation. We must recognize and separate the creative person from the circumspect and apply the talents of both to the proper phases of product development. Any analysis of the subject of idea generation and specialization must also recognize the difference between Product Planning and Product Development. The first should be broad and creative (objectivity); the second, analytical and specific (subjectivity).

What the industrial designer can do

It matters little whether engineers, designers, marketing people, or presidents supervise the Product Planning function. The important point is that it be broad in viewpoint and thorough in creative scope. Initial ideas are going to come from many sources, from field sales personnel to shop men. The difficult problem is not just ideas, but the expansion of ideas so that development decisions can be based on a well-rounded choice. Someone has to care—about ideas in general and about quantity and quality of ideas—and yet not become personally attached to any one pet idea and favor it over others. "Idea expansion" is my term for the creative brainstorming process that should be applied to all reasonable and new ideas so that committees and product groups can make sound evaluations before initiating an extensive development program. The expansion of ideas is an area in which I believe the industrial designer can contribute most effectively. By nature he is inclined toward flexibility of imagination and is sufficiently a rebel not to be unduly limited by currently competitive concepts. His ability to visualize and sketch freely, plus his interests and attitudes that broaden both engineering and marketing, provide him with a faculty for devising 10 possible variations for each idea submitted.

The value of idea expansion is frequently overlooked in new-product programs. Without a thorough study of possible variations on an idea, competition is often able to second-guess you and improve upon your idea. Until you expand an idea into 10 ideas and weigh the 10 against each other, you have not protected yourself against your competition's more objective viewpoint. As in research work, only 5% of the total ever results in a tangible asset but you can't tell which 5% until you eliminate the other 95%.

It is impractical in today's competitive market for engineers or any individual or group to be the sole source of new-product ideas. But it is certainly of value to engineers to develop means of more adequately contributing to sound product programs. Rather than attempt to be the sole source, the engineer could do himself and his company a greater service by organizing and utilizing other specialists for mature, broad and timely programs.

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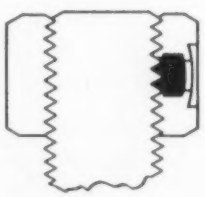
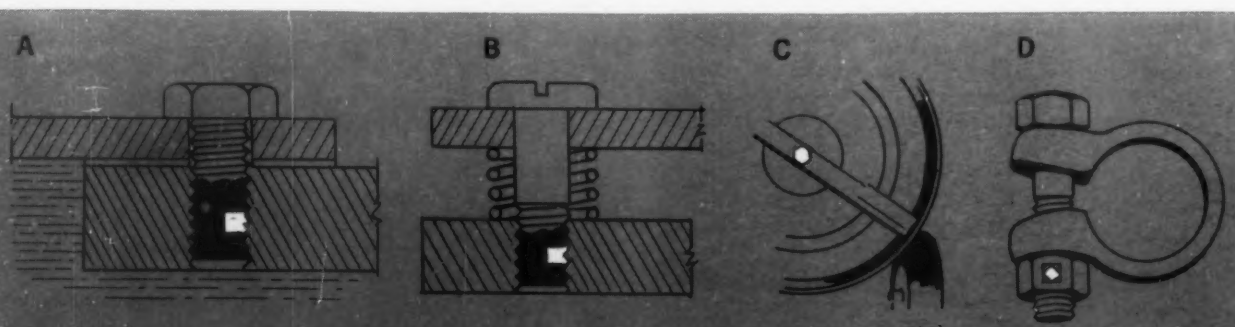


Typical NYLOK applications: (a) NYLOK Bolt as a fastener-sealer to effectively block fluid escape along thread path; (b) NYLOK Bolt used to solve tension or vibration fastening problems; (c) NYLOK Nut used to secure lawnmower rotor blade under severe vibration conditions; (d) NYLOK Nut employed to lock tight against pressure of a spring-clamp.



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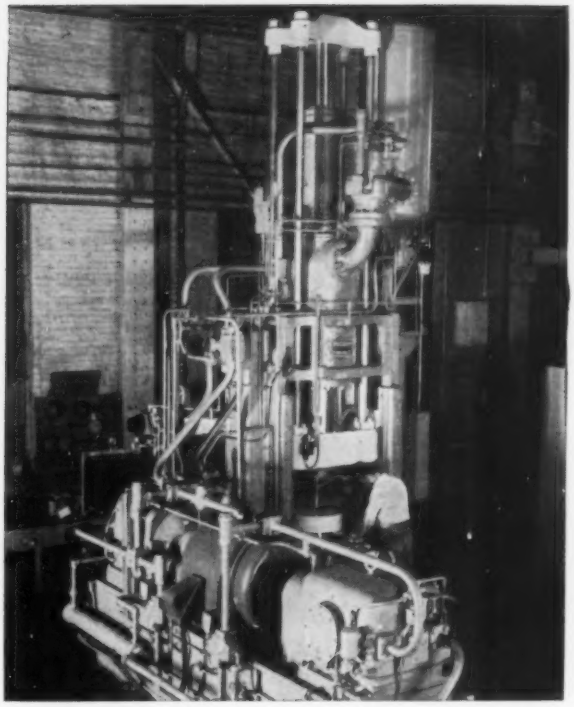

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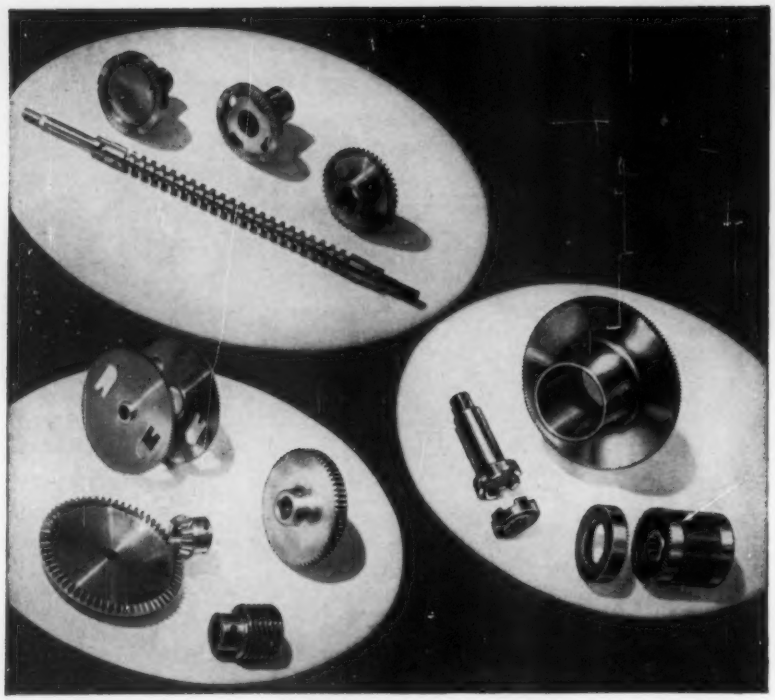

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YOURS ON REQUEST Folder showing custom gears Perkins has made (from various materials) for aircraft, automotive, precision instruments, home appliances, portable and machine tools, and other products. Includes Perkins facilities for producing various gear types and sizes. *Write today.*

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READER TO EDITOR

Automated Mail Talks Back

To the Editor:

The opening words of "Mechanical and Personnel Problems Plague Automatic Post Office," Mar 20 p 17, are a little disconcerting to Stewart-Warner, because they are rather all-inclusive. The point is that Stewart-Warner has been doing some "streamlining" in this matter of mail handling, and it has been highly successful, not fraught with the frustration nor productive of foul-ups of the type described by your staffer.

Our mail-sorting systems are busily sorting and stacking mail, untouched by human hands (virtually) after the sacks or parcels reach our systems. Our grandest example, to date (and soon to be dwarfed by a bigger one!) is at the Union Depot, in St Paul, Minn. Our newest one is about eight blocks south of your office, on the 9th Ave side of Penn Station, two levels down. It is sorting parcel post mail, making some 36 or so "sorts."

Now just so you'll know this isn't a pipe dream of the writer, kindly look over the attached letter from Bill Howery, V-P and general manager of the St Paul Union Depot company, plus summary of comparative operating costs before and after buying our machine. —Ted Grange
Stewart-Warner Corp

• Mr Howery's letter shows accumulated savings in the first 10 months of operation (Mar to Dec '60) of $475,000, as compared with the same period of 1957. "Feed of mail" on and off trains rose from 872,312 in 1957 to 911,458 in 1960, while man-hours worked dropped from 910,435 to 802,621 in the same period. Man-hours per foot averaged 1.022 in 1957 and 0.833 in the last 10 months of 1960.

As we said in "Turn Back the Clock" (*Jan 16 '61, p 32*) there has been constant pressure against Post Office progress in Washington—determined effort to stick with manpower despite obvious difficulties and expense. During the last session of Congress, Senator Kefauver introduced S. 3132 to prevent "the use of stopwatches or other measuring devices in the postal service . . ." Now our new Postmaster General has been making political capital out of indicting all the moves of his predecessor toward automation of the mail. This latter attack has some basis in costs and startup difficulties at some installations, but fails to mention others that are working, or the fact that our present "system" is a shambles. Mr Grange is actually discussing parcel post-handling systems operated by the railroads, not letter-handling systems operated by the Post Office. We accurately reported on the latter, based on interviews in Washington. —EJT

Specs for High-pressure Teflon

To the Editor:

I am concerned about your Feb 20 article, "Industry Splits Over Specs Needed for High-pressure Teflon" (p 20) because of its indication that a real battle is

supposed to be going on in SAE over two types of hose construction. As far as I know, there is no such battle. I can't think of any source, except our committee itself, from which such information could have been regarded as authoritative.

If there were such a battle at this time, it would be indicated by discussion within the committee. Discussion is far from being concluded in regard to the documents describing the hose assemblies mentioned in your article. Actually, the committee so far has merely been engaged in a survey to see whether or not enough demand for ARF 619 exists to warrant further work. Until results of that survey are integrated into a final committee report, and that report approved by the SAE Technical Board, no information suitable for general publication can possibly be entirely current.

I think you will agree it would be inappropriate for me to get in a position where I might be required to referee a technical argument erected by a published article which, from my viewpoint, was not based on authoritative information. Such refereeing would be as inappropriate, I believe, as release of the information by unofficial sources and its subsequent acceptance from those sources as the basis of an article. —R W PHILLIPS, *chairman SAE Committee G-3*

COMING EVENTS

MAY

7-11 . . . . American Society of Mechanical Engineers, Engineering Institute of Canada, Hydraulic Conference, Queen Elizabeth Hotel, Montreal

8-9 . . . . American Society of Mechanical Engineers, Lubrication Symposium, Hotel Deauville, Miami Beach

8-10 . . . . Institute of Radio Engineers, 13th Annual National Aerospace Electronics Conference, Biltmore & Miami Hotels, Dayton, Ohio

9-11 . . . . Western Joint Computer Conference, Ambassador Hotel, Los Angeles

9-11 . . . . Institute of Radio Engineers, 1961 Electronic Components Conference, Jack Tar Hotel, San Francisco

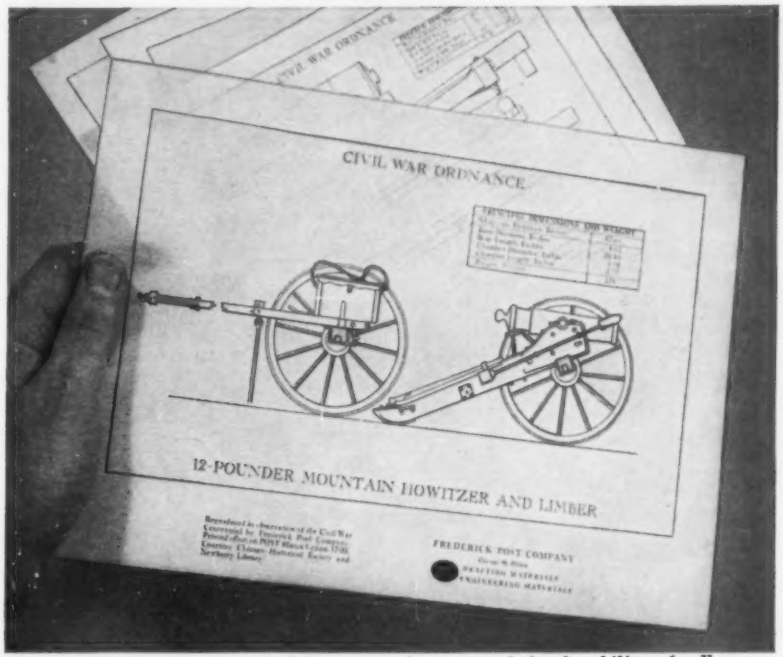
10-12 . . . . Society for Experimental Stress Analysis, Spring Meeting, Benjamin Franklin Hotel, Philadelphia

14-17 . . . . National Fluid Power Association, 1961 Spring Meeting, The Greenbrier, White Sulphur Springs, WVa

22-25 . . . . American Society of Mechanical Engineers, Design Engineering Conference & Show, Cobo Hall, Detroit

For a listing of addresses of societies and associations send 25¢ to Product Engineering Reader Service Dept, 330 W 42nd St, NY 36. Ask for brochure R 32.

DRAFTING TRENDS



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First, fill in and return the appraisal form furnished with the POST Blutex sample. In appreciation, a handsome portfolio of four Civil War Centennial ordnance prints, on POST Blutex Vellum, suitable for framing, will be sent to you. Write Frederick Post Company, 3642 North Avondale Avenue, Chicago 18, Illinois.

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ENGINEERING EQUIPMENT & DRAFTING SUPPLIES • FIELD EQUIPMENT & DRAFTING FURNITURE

CIRCLE 29 ON READER SERVICE CARD

Dependable Natural Gas Power...

A milestone in public education was reached this year as a Clearwater, Florida school experiment set out to compare air-conditioning operating costs and student achievements. Although building contracts for the new schools were comparable, the air-conditioned school, above, actually cost less to build because design was more compact, with reduced roof and corridor construction. At left, 7th grade science students stay cool and fresh, sustain interest throughout the day in climate controlled classroom.

Florida project relies on International engines to keep operating expense at reasonable level...

A new era for municipal air-conditioning may be the result of a school project getting underway in Clearwater, Florida. It is believed that climate control in the classroom will improve student comfort, promote alertness, reduce illness and absenteeism, and generally upgrade the education of our children. Although industry has universally accepted the merits of air-conditioning, school and municipal officials question its value when confronted with the cost and operating expense of reliable cooling equipment. The Clearwater project will answer this question.

The project began with construction of two junior high schools—the Oak Grove School in Clearwater and the Pinellas Park School in St. Petersburg—each one comparable in cost and capacity. The Clearwater school is air-conditioned, the other is not. Comparison of operating expenses and educational achievements during the 1961-62 season will determine if climate control is worth the extra appropriation.

To keep operating costs at a minimum, school officials chose a natural-gas-powered system with outstanding characteristics of economy and efficiency —two Ready-Power 60-ton units driven by two International U-450 engines. The IH-powered system operates from 9:30 am to 4:30 pm, bringing classroom temperature to the desired level within 30 minutes. Water enters the line at approximately 90° F and leaves the system at 48° F. Return water is approximately 51° F. The separately-housed system keeps 24 classrooms and the gymnasium at about 72° F regardless of outside temperatures.

When you turn to International for air-conditioning power, you join an ever-increasing number of engineers and contractors who specify IH engines for dependable, low-cost installations. The wide range of sizes in the IH line—35 diesel and carbureted models from 16.8 to 385 max. hp—gives you matched power for all heavy-duty jobs. For complete information contact International Harvester Co., Engine Sales Dept., Melrose Park, Ill. For specific information on air-conditioning, fill out the coupon on the page opposite.

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ENGINES

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180 North Michigan Ave., Chicago 1, Illinois
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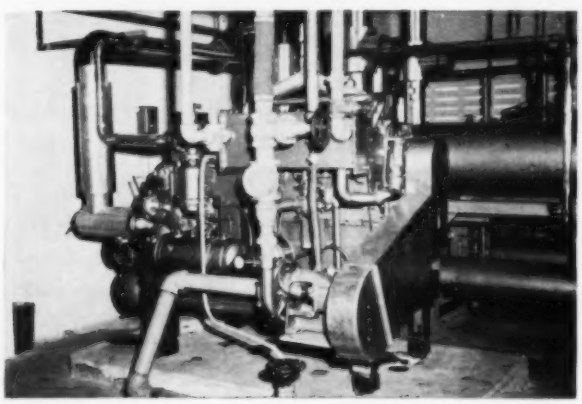
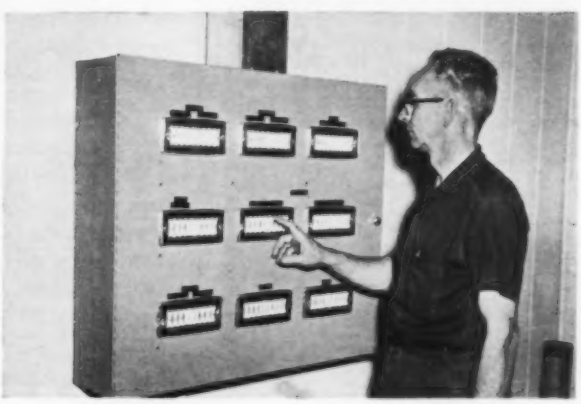
New Key to Low-Cost Municipal Air Conditioning



Officials who specified cooling equipment for the Clearwater project naturally turned to the most economical units they could find. Two natural-gas-powered International U-450 engines drive two Ready-Power water chillers in this low-cost system. Installations throughout the country indicate that International engines provide the most economical air-conditioning power available.



Operating Engineer J. E. Pratt controls temperature of each room and gymnasium from this master panel. Each classroom accommodates 35 students. The school began with 665 students, now has a total enrollment of 1,200. Provisions have been made for additional air-conditioning equipment as extra rooms are added to the present facility.

For descriptive literature spelling out the advantages of International natural gas powered air-conditioning, send for colorful, illustrated booklet. Fill out the coupon and mail it today!

Mr. R. R. McKiel
Engine Sales Dept.
International Harvester Co.
Melrose Park, Ill.

Please send me the booklet on natural gas air-conditioning.

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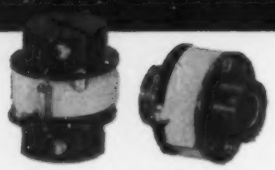
CIRCLE 31 ON READER SERVICE CARD

TIC OF ACTON

MINIATURE FLEXIBLE COUPLINGS



FEATURE • No Backlash • Compactness and Lightweight • Accommodate both lateral and angular misalignment • Choice of types offer clamping or set-screw hubs

Type MPC-1 consists of two flanged aluminum hubs and nylon or Delrin discs with V-grooves that are displaced 90° with each other. Discs are fastened with stainless steel springs loading ball pivots against V-grooves. Dimensions ⅞ x ⅞ in.
Type MPC-2 has two cylindrical aluminum hubs, each with two ball pivots attached. Hubs are attached to a pair of flexible phosphor bronze discs which hold and load the ball pivots. Dimensions ¾ x ½ in. Both types have range of bores to accept shafts from .120" to .250" and meet MIL-E-4970 and withstand −80° to 200°F and shock to 100 G.

TIC OF ACTON

ADJUSTABLE SLIP CLUTCHES

FEATURE • Adjustment over a wide torque range • Compactness and lightweight

Type ASC-1 is ⅞ x 1"
Type ASC-2 Miniature is ⅝" x ⅝"
Both are constructed of aluminum hubs, Delrin* on stainless steel clutch plates and stainless steel hardware. These rugged, high performance clutches are friction units to protect components against excessive or inertia shock loads. Range of bores to accept shafts from .120" to .250". These clutches meet MIL-E-4970 specs.
For details on couplings or clutches write

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TECHNOLOGY INSTRUMENT CORP.
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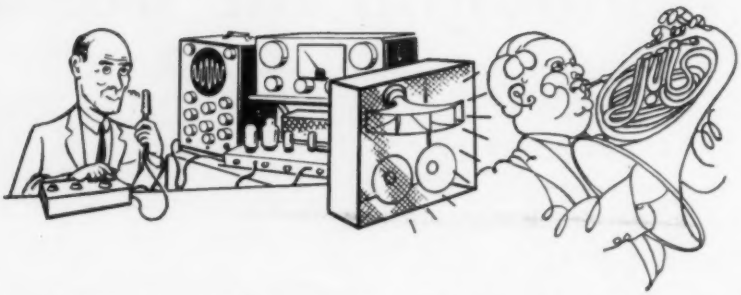
533 Main Street
Acton, Massachusetts

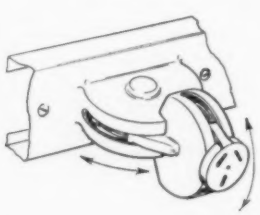
WHY DON'T THEY R&D..?



. . . an electronic musical instrument that could be played by anyone who can hum a tune. This would be kind of a "super-kazoo"—melody would originate in an electronic mouthpiece into which the user hums. Signals from the mouthpiece would pass to a wave-shaping and augmenting network where they would be transformed into signals that simulate waveforms of familiar wind instruments—clarinet, trombone, trumpet, oboe, tuba—depending on the adjustment of the circuits. These modified signals would then be amplified and reproduced through a conventional hi-fi system. With wiring circuits, several "instruments" could be played through the same system. —C PERKO

. . . ready-made, hardfaced insulating panels that could be cut and finished to meet the requirements of any manufacturer. At present, when insulating panels are needed for the manufacture of furnaces, cold boxes, etc., they must be expensively hand-assembled using a metal or plastic facing, backed with 1 or 2 inches of an insulating material such as rock wool or glass fiber. The problem in making a preassembled panel is finding a binder that will hold the loose insulating material together at temperatures from 400 to 800 F. Panels should be made up in 4 x 8-ft sheets with a variety of thicknesses for different temperatures: 1 in. for up to 400 F; 1.5 in. for 600 F and 2 in. for 800 F. These could then be bandsawed to shape and painted. It is important that the binder not increase weight or decrease insulation properties appreciably. —R A STONE

. . . a portable, battery-powered, soldering gun for electronic service men. Some present soldering guns operate on 6 or 12 volts from a step-down transformer. Why not supply the current from a small rechargeable battery in the handle of the gun? Life of charge would be quite short but would be sufficient for most service calls. Battery would be recharged between calls by plugging into cigaret lighter of service truck. —R MARIE



. . . a swivel socket for bench outlet strips. The cords plugged into them could hang down (or point up) without bending the cord just behind the plug, where most cords fail. Mounting a conventional outlet so that it points down is not practical—you can't see where to insert the plug. The outlet should swivel through 180° in a vertical plane and preferably through about 120° in the horizontal plane. —D J BRYANT

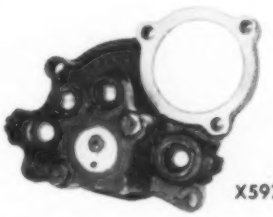
Have you a problem, based on known scientific principles, which seems to have an answer somewhere within the limits of present technology? To inspire inventors along worthwhile paths, PRODUCT ENGINEERING invites you to trade such problems with fellow readers who have a fresh viewpoint or more time to experiment. We pay $10 for each one accepted.

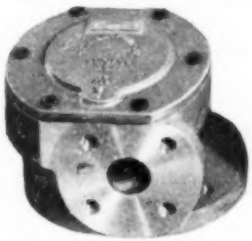
X250

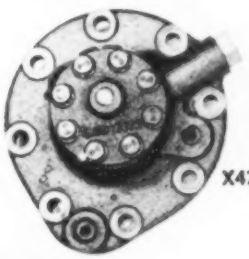
X585

X429

LDK


X597


X543


X476

for those special applications . . .

TUTHILL fits the pump to the PROBLEM

Here you see seven pumps . . . each designed to provide the best possible answer to one specific problem. They are typical of the many special application pumps developed each year at Tuthill.

For, while Tuthill offers over 800 standard models, often a customer's particular requirements indicate the desirability of special features not included in the standard line. For these applications Tuthill attempts to develop a pump to fit the problem . . . not require the user to modify his problem to fit a standard line.

Special housings

The seven examples shown indicate Tuthill's versatility in developing special housings for different types of equipment. For example, number X250 above was designed to provide a pump for a hydraulic actuator on a machine tool. The most convenient place to install this pump was on the hydraulic column . . . so the special mounting shown was designed. Most of the other unusual shapes shown above were similarly devised for greater convenience and lower assembly costs in building a pump into a particular piece of equipment.

Special materials, shafts, gearings

This versatility of housings and mounting arrangements only begins to indicate Tuthill's ability to best meet the requirements of a given application. As another example, models number X543 and X585 have bronze outer construction, and other features which particularly qualify them for marine applications. Model X429 above incorporates Tuthill's special automatic reversing feature. This means the pump may be driven from a reversing shaft . . . or provides for applications where a machine must be shipped without knowing the ultimate direction of the driving unit.

Tuthill pumps may be supplied with a wide variety of shaft seals for use with various fluids. They can incorporate strainers, as model X585 above. They may be provided with, or without, built-in relief valves. They can incorporate a wide variety of special shaft modifications or gearing to accommodate various driving units.

They may be provided with steam jackets for use with viscous fluids. They may be also shipped as stripped models that can be built right into your equipment.

Tuthill's experienced application engineers will be happy to show you how Tuthill can develop a pump to fit the requirements of your particular application. Write today for a copy of catalog 100.

Tuthill manufactures a complete line of positive placement rotary pumps in capacities from 1 to 200 GPM; for pressures to 1500 PSI; speeds to 3600 RPM.

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A delivery schedule is a promise made—one to be kept. And we're proud of General Electric's Form G record on that score.

A total of five highly automated manufacturing lines in three separate plants stands ready to make sure you get the exact fhp motors you ordered . . . and get them when you want them.

In addition to fine delivery performance, you get these MORE THAN A MOTOR benefits with General Electric Form G motors: *Years-ahead Design Leadership . . . Expert Application Aid . . . Versatility Personified . . . Ease of Assembly . . . Fast, Local Service.*

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1. RELIABLE SWITCH—Centrifugally-operated switch has been life-tested to last for more than 3,500,000 operations. Dependable switch mechanism operates with positive snap action.

2. LONG-LIFE STATOR—heavy-duty stator bonding dip and Mylar* insulation protect against damage caused by heat, stress, moisture. Stator clamps provide additional rigidity.

3. RUST-RESISTANT SHAFT—special gunmetal-like treatment of motor shaft resists rust and corrosion, simplifies product service. Fans, pulleys, and couplings are easy to remove.

4. LONG-LIFE LUBRICATION—over 50% more oil than in old-design motors and an efficient oil retention system contribute to motor's doubled lubrication life; cut maintenance.

5. THRUST PROTECTION—Interlocking washer assembly withstands normal thrust from any direction, regardless of motor angle. The assembly also acts as an oil seal for long motor life.

6. COMPLETE LINE—Over 850 basic models—and literally thousands of variations—mean there's a standard General Electric Form G motor to meet your product's exact requirements.

* Registered trade-mark of Du Pont Co.

You get these *added values* at no extra cost. So why settle for less?

Form G fhp motors are available in NEMA 48 and 56 frames. For more information, call your G-E Sales Engineer or write for bulletin GEA-6424 to Section 721-10, General Electric Co., Schenectady 5, N. Y.

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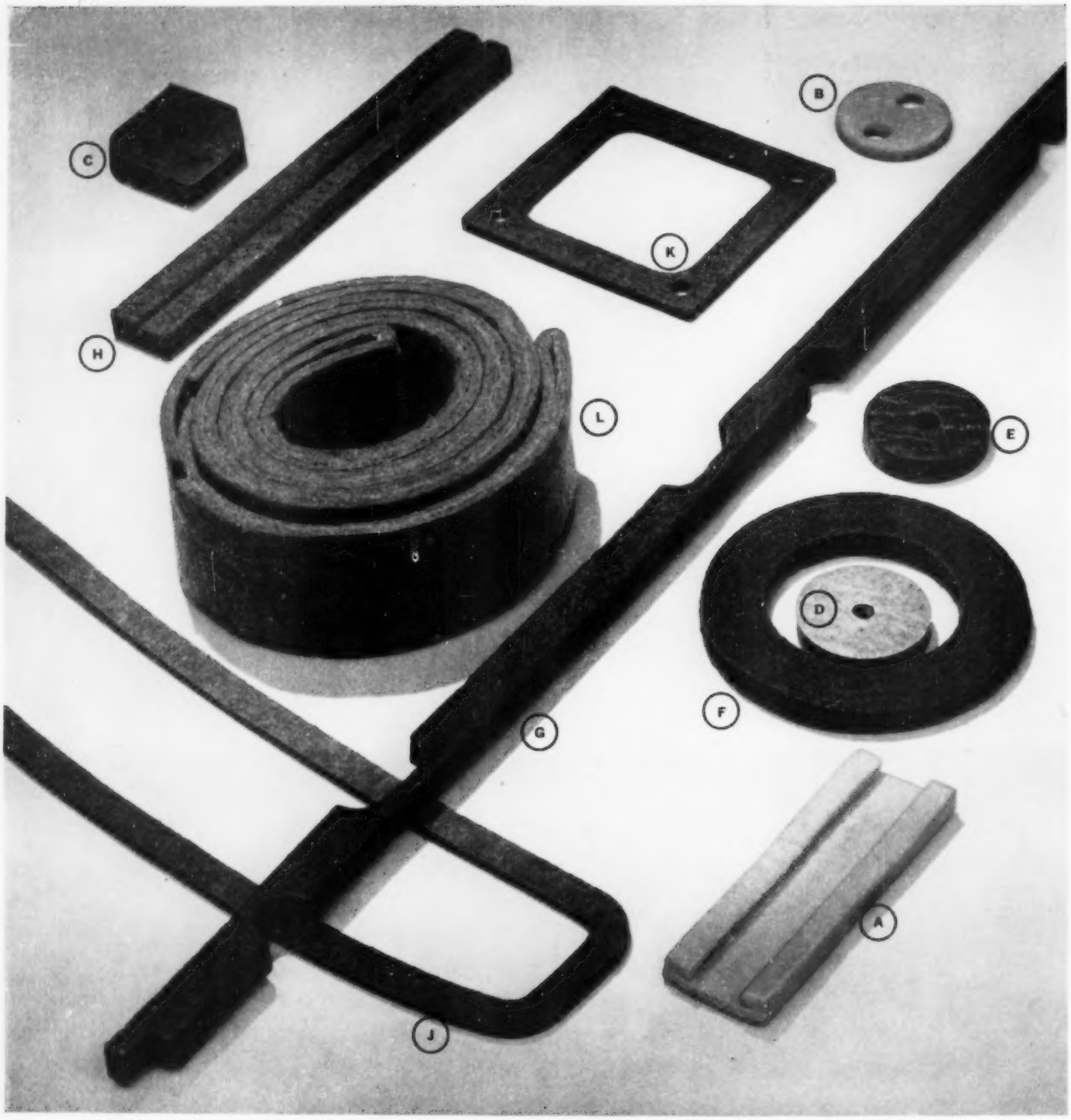
GENERAL ELECTRIC



DO YOU need a versatile engineering material to repel water, stop rust, stop dust? Or a material that is flameproof or mildewproof . . . resistant to sound, odor, friction, acid, alkali, oil, heat, cold or wear? Think of Western Felt.

Western Felt can supply over 92 different **TREATED FELTS** to meet your specifications and give special protection long after other materials break down.

A—Flameproofed felt rattleproofs fire extinguishers.
B—Mildewproofed felt repels water while lubricating air conditioners.
C—Polyethylene-treated felt around car clutch arm stops dust, motor noise, odor.
D—Polypropylene-treated felt around accelerator rod resists friction, acids, alkalies, organic solvents.
E—Resin-coated felt around clutch arm resists oil and water, seals off driving compartment.
F—Wax-impregnated felt resists water—makes an extra-firm steering-column seal.
G—Waterproofed felt bars water and dust from gear box.
H—Adhesive-coated felt quickly affixed, lubricates porcelain shoe on clothes dryer.
J—Wax-impregnated felt repels water, prevents corrosion, seals junction box on truck trailer.
K—Hycar-impregnated felt resists abrasion and wear—seals lint trap on clothes dryer.
L—Teflon-coated, latex-impregnated felt around clothes dryer drum reduces friction, motor load—withstands heat. Tensile strength extends dryer life.

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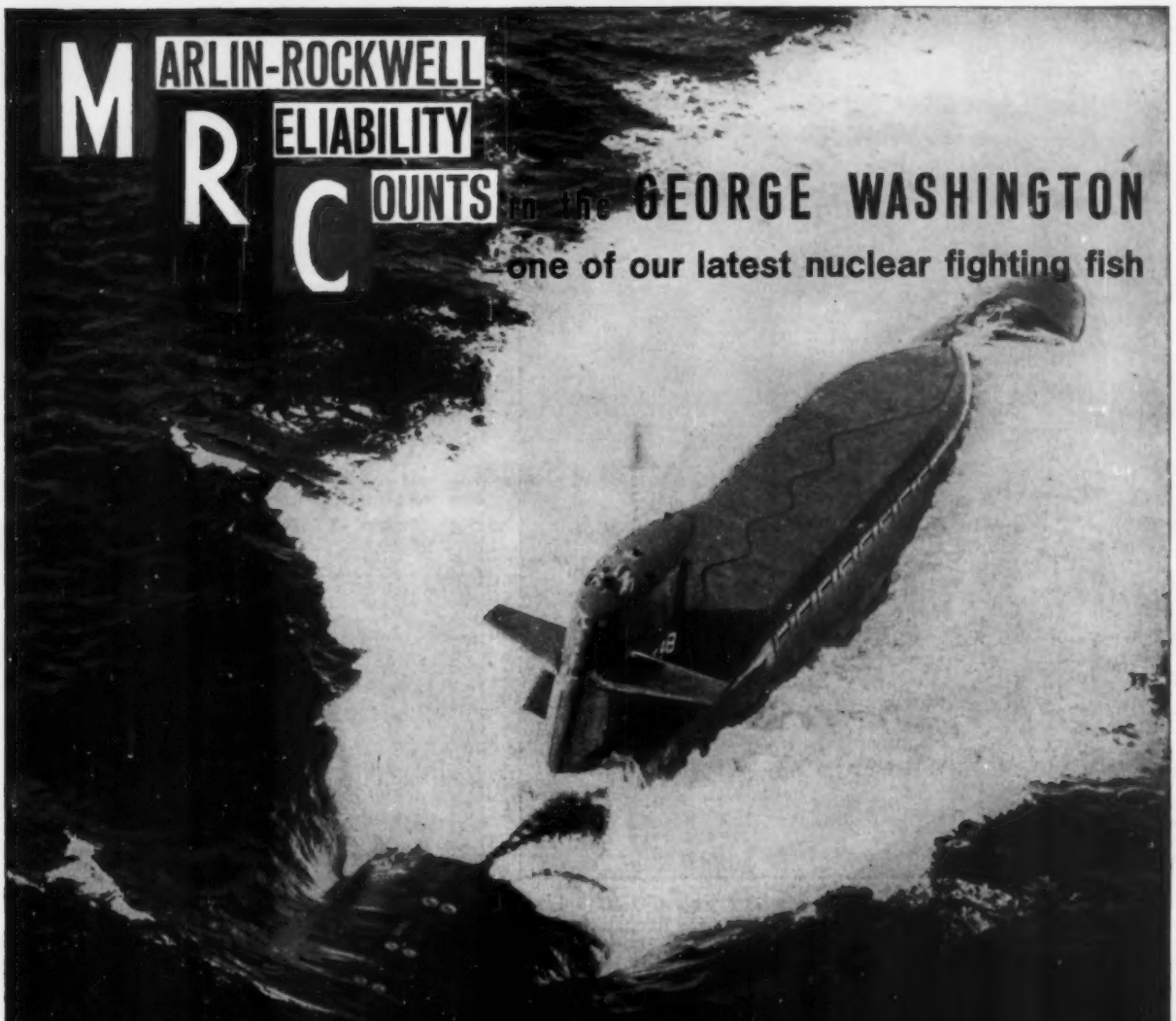
MARLIN-ROCKWELL RELIABILITY COUNTS in the GEORGE WASHINGTON

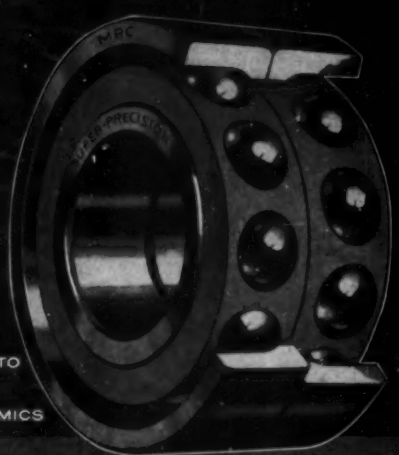
—one of our latest nuclear fighting fish



MRC Engineers, working with the country's leading electric motor manufacturers, have developed the world's quietest, smoothest running and vibration-free bearings for use in the electric motors of our nuclear powered submarines.

While most applications do not require bearings with such extremely close tolerances, the techniques developed to produce these highly successful bearings are employed in manufacturing other bearings to tolerance levels commensurate with the equipment in which they are to be used.

These achievements have contributed greatly to the general overall performance expectations of all types of bearings for any critical applications.



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Consult OUR Engineering Department on YOUR Bearing Problems

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BALL AND ROLLER *bearings*

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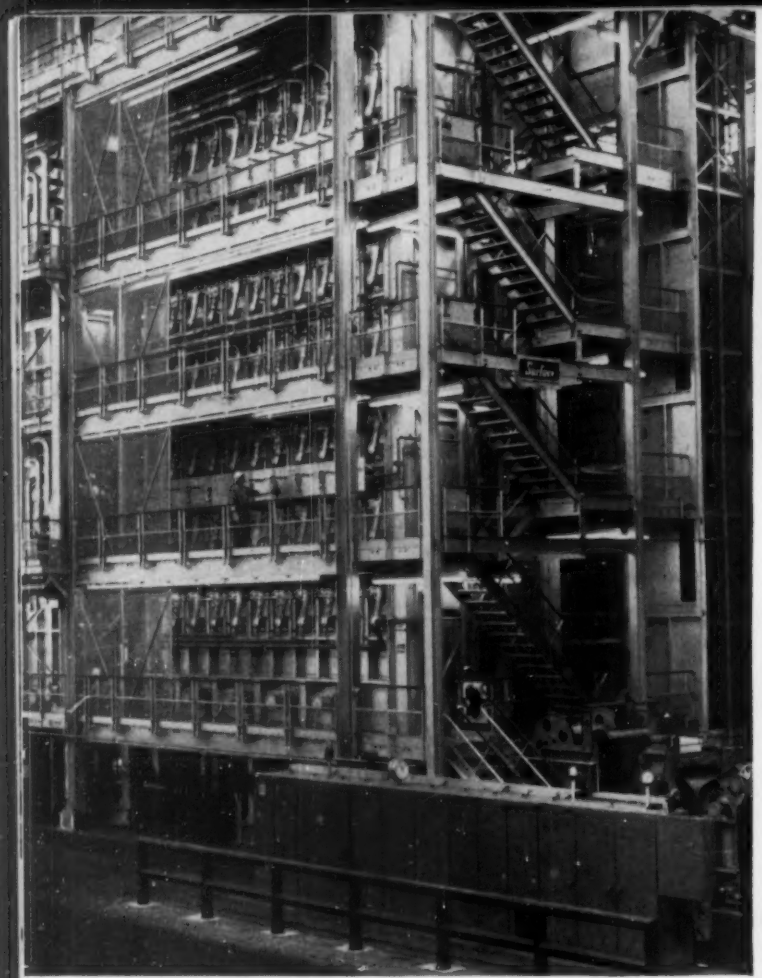
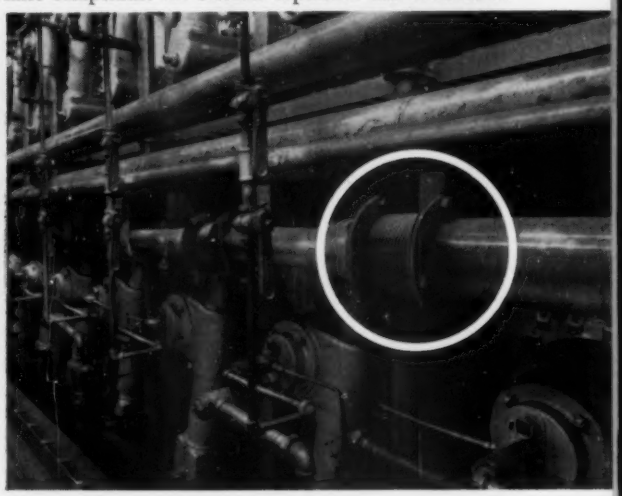


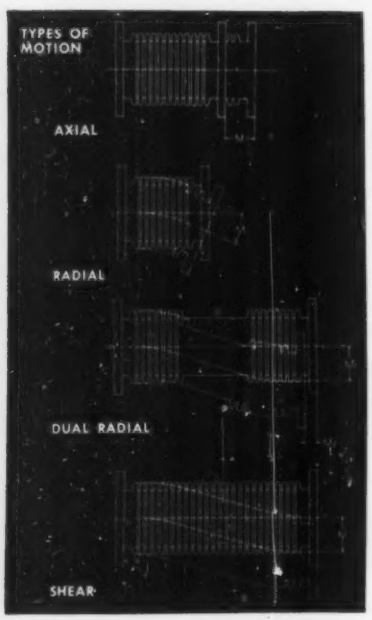
A view of the U.S. Steel's giant annealing furnace in Pittsburg, Calif. Coils are welded together so that a mile-long strip is constantly moving through the series of heating, soaking and cooling zones in roller-coaster fashion at speeds up to 1500 feet per minute.

Anaconda A-X flexible connectors installed at roll-shafts absorb thermal expansion and contraction and seal in inert gas furnace atmosphere.

Anaconda A-X stainless steel flexible connectors on flue-gas lines compensate for thermal expansion and contraction.



ANACONDA A-X FLEXIBLE CONNECTORS PROTECT PIPING, SEAL ROLL-SHAFTS IN LARGE ANNEALING FURNACE



Continuous strip annealing furnace temperatures cause a variety of movements due to thermal expansion and contraction. To absorb this movement in flue-gas lines and to provide shaft seals on rolls, Surface Combustion Division of Midland-Ross Corp., designers and builders of U.S. Steel's giant furnace, installed hundreds of Anaconda A-X stainless steel flexible connectors.

Anaconda A-X Tubing is a flexible metal connector designed to handle the types of movement shown at left while conveying liquid and gas over a wide range of temperatures. It is available in stainless steel and other alloys and is generally sold complete with fittings. Nominal tubing I.D.'s: 5″, 6″, 8″, 10″, 14″. For complete details, write for Bulletin A-X 97 or call your Anaconda Metal Hose representative. Anaconda Metal Hose, Box 791, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont. 61129

ANACONDA® METAL HOSE

CIRCLE 38 ON READER SERVICE CARD

PRODUCT ENGINEERING HORIZONS

MAY 1, 1961

Those very LIBERAL Arts

"Engineers need more liberal arts." "How can the engineer take his place in society without training in the humanities?" "Engineers are too specialized."

These are familiar remarks, as competent as a wood tick in burrowing under an engineer's skin. We've accepted them, believed them, because of the frequency with which they've been made, the authorities who made them, the emphasis on getting along with people as the high road to advancement. Now comes the Institute of Higher Education of Teachers College, Columbia University, with a 132-page report, "Liberal Education and Engineering," from a grant made by the Carnegie Foundation. Asks the report: "Can the engineer perform the larger functions of industrial management, government policy making and public leadership—which are increasingly his lot, whether he wills it or not—unless his education is much broader than that represented in the more technically oriented institutions?"

A cold-blooded answer might be, "Of course he can—and is—or his opportunities to do so would *not* be increasing." But there is much more to it than that. Are we to be drafted to run our economy whether we will it or not? Are we to become the human equivalent of worker bees or draft horses, bred and trained for specialized jobs? Is the engineer to have no choice of career—no opportunity to stay in engineering rather than be forced into management? Come now, Columbia!

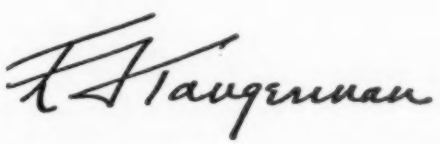
The report goes on to say that about 20% of current 4-year engineering curricula are devoted to the social sciences and humanities, recommends that this percentage be increased to at least a third, that engineering schools should provide students with a "broad knowledge of the major areas of learning," that they are "certainly more narrowly professional than they should be."

Such statements, in the face of the geometric increase in engineering and scientific information to be imparted, suggest a 5-year curriculum or advanced degree. Both ideas have their proponents and their opponents, but the "anti" group would be markedly increased if the added time were earmarked for more liberal arts. There are presently available engineering curricula incorporating both ideas, so the student can pick and choose.

Some authorities feel that the humanities are not "taught" but "caught" anyway—that the receptive youngster will receive much of his cultural background at home and in secondary schools, and that the engineer-oriented student consciously or subconsciously resents the time spent on these subjects during engineering training, so very little of it is retained. His later life determines whether he wants or needs it.

Our engineering schools might well offer to go even higher than the suggested 20% figure. They must, however, point out (very diplomatically, of course) that they agree on a reciprocal basis—that liberal-arts colleges insert an equivalent amount of engineering studies in their curricula.

This would have several salutary effects: More of our humanities graduates would have a realistic attitude toward life today and might understand the engineers' problems—and how to change a fuse. More humanities graduates would be able to undertake the management duties, the policy making, the public leadership, thus relieving the engineers of that unwanted chore—and incidentally improving the quality of decision-making in those three presently maltreated areas. It might reduce the number of "pipe" or "gut" courses presently available to the liberal-arts student who is seeking a degree for reasons of status. It might reduce the pressure from the liberal-arts bloc. And it might get us back onto the track—the realization that much of the social-sciences and humanities curriculum can be self-taught, as the engineer feels a need for these graces, but that basic engineering must be thoroughly learned at the beginning if it is to be learned at all.



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TECHNICAL DATA ON

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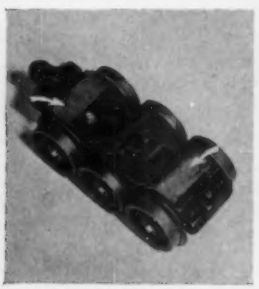
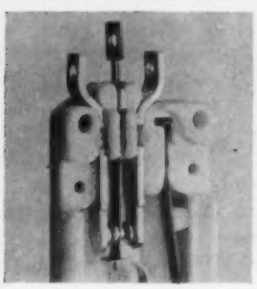


"Teflon" to steel . . . Alnico to zinc die cast . . . glass to brass . . . carbide to stainless . . . rigid plastic to copper . . . ceramic . . . stainless . . . cast iron . . . magnesium . . .



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which SHOCK-ABSORBING SYSTEM will do the job?

If you have one in mind, check to see if it will work by making a few quick calculations with the efficiency factors listed here for 8 systems. If it doesn't, find a better choice in this article's detailed analysis and comparison table.

G REINERT, *engineer, Kollsman Instrument Corp, Elmhurst, NY*

Suppose you are designing a system that has to absorb a given amount of energy, but there are limits on the amount of force that may be transmitted, and the amount of deflection allowed. Which shock-absorbing system should you choose?

Some may not be able to meet the given requirements, no matter how you modify their dimensions or materials. So it's important to know whether or not the system you have in mind will work, before spending time to check its design. And once you know the efficiency of a shock-absorbing system you can make a quick estimate of size.

For a specified maximum deflection and transmitted force, the maximum amount of energy that any shock isolator must absorb is fixed, and is generally the product of force and deflection. An inefficient absorber means that the available space is not utilized to give maximum protection to the equipment. Thus, for a given condition of shock (such as dropping a package from a certain height), the more inefficient absorber will require either a larger deflection or offer less protection to the equipment by transmitting a larger force.

The shock-absorbing efficiency of a system is a dimensionless factor (see Symbols):

$$E = \frac{\int_0^{x_m} F\,dx}{F_m\,x_m} \qquad (1)$$

The force-deflection curves starting on page 42 give a visual comparison of shock efficiency for eight most popular systems. This efficiency is the ratio of the shaded area under a curve to the area of the rectangle bounded by the maximum-force and maximum-deflection lines. Anything which fills out the unshaded area of the rectangle without raising the maximum point of the curve will increase the efficiency. Factors which affect efficiency include spring-rate linearity, preloading, damping, and friction.

The efficiency equations given here can be extended to problems involving rotation by substituting torque for force, angular deflection for linear deflection, and mass moment of inertia for mass. One of the sample problems that follows illustrates such a case.

The table on page 44 summarizes the various types of shock-absorbing systems and compares their efficiency ranges.

continued, next page

SYMBOLS

- b = thickness of Belleville spring, in.
- c = coefficient of damping, lb-sec/in.
- C = Belleville-spring constant determined by material and dimensions, lb/in.^{3}
- e = base of natural logarithms = 2.7183
- E = shock-absorption efficiency
- F = transmitted force, lb
- F_m = maximum transmitted force, lb
- g = acceleration due to gravity = 32.2 ft/sec^2
- G = acceleration due to shock impact, in g's
- h = height of Belleville spring, in.
- H = drop height, in.
- I = moment of inertia, in.-lb-sec^2
- k = spring rate, lb/in.
- M = mass of unit to be protected, lb-sec^2/in.
- n = rotational speed, rpm
- t = time, sec
- T = torque, in.-lb
- V_0 = velocity of mass at instant of impact, in./sec
- W = weight of mass, lb
- x = deflection of shock absorber, in.
- x_m = maximum deflection, in.
- θ = angular rotation, radians

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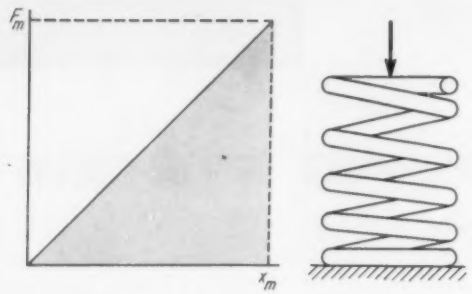
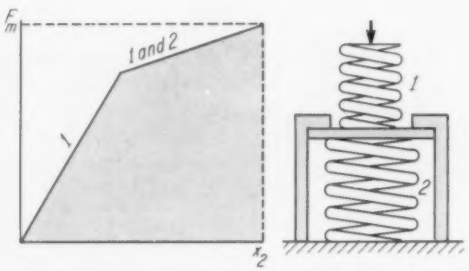


1 Linear springs

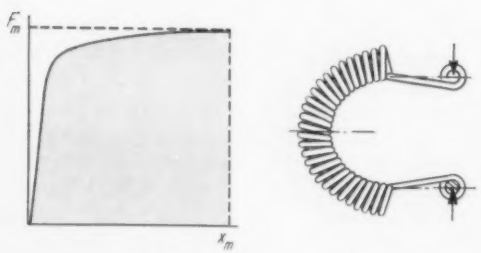
Metal helical springs have little damping and show linear characteristics. The load-deflection curve shows a triangle; therefore, efficiency is ½ or 50%. Although commonly employed, the helical spring has one of the lowest efficiency ratings and tends to cause excessive amplitudes during vibration at resonant conditions. It should be avoided in shock applications.



3 Multirate spring with decreasing rate

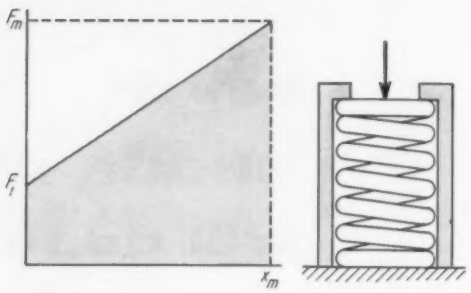
In the dual-spring system, an increasing load causes only spring 1 to deflect until the load equals the preload of spring 2—then both begin to deflect.

Spring 1 can also be preloaded to further increase the efficiency rating. Triple-rate assemblies with three springs have been successfully used in aircraft controls.



4 Constant-force devices

These have almost flat force-deflection curves and have very high efficiencies. A spring system with a flat curve has 100% efficiency—but this is difficult to obtain. Examples of almost-constant-force devices are flexible helical springs (illustrated), hydraulic shock absorbers with special valves, prestressed metal tapes, and materials with honeycomb or buckled-lever configurations. The special materials are extensively used in packaging.



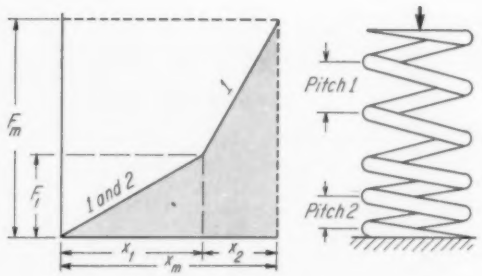
2 Preloaded springs

Preloading a spring that is not as stiff as the one shown previously, improves the efficiency without exceeding the maximum force. The efficiency for a preloaded spring is:

$$E = \frac{F_1 + F_m}{2F_m} = 1 - \frac{kx_m}{2F_m} \qquad (2)$$

Preloading is a relatively simple method of obtaining high efficiencies. The resulting initial stresses in the spring and its support, however, may be undesirable in certain applications.

A spring system damped with dry friction also has the above load-deflection characteristics. But dry friction is an unreliable factor in design because accurate values are difficult to predict.



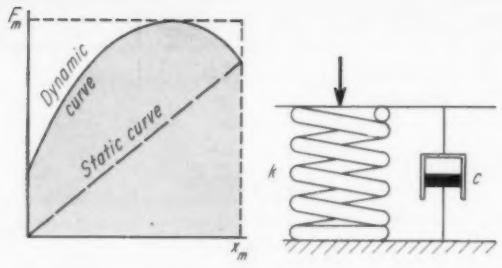
5 Multirate spring with increasing rate

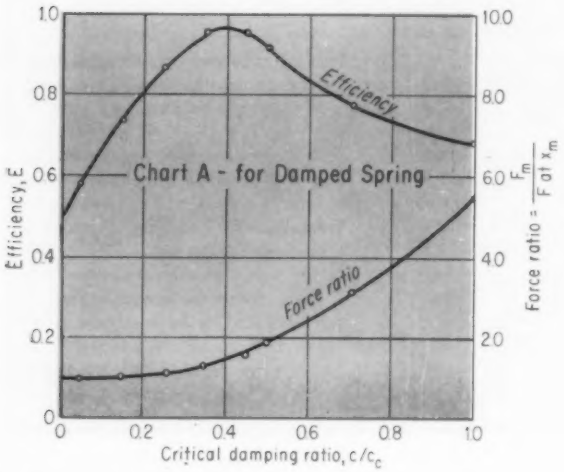
Helical springs will give multirate characteristics if made with coils of dual pitch, or if properly preloaded and stacked in series. Both of these methods can be varied to give either an increasing or decreasing load-deflection rate.

The increasing-rate system above provides a low transmitted force for most of the expected shocks, and a stiffer rate to protect against the occasionally heavier shock. It is frequently employed in aircraft control applications. Under an increasing load, both sets of coils deflect until the lower coils bottom out, leaving only the top coils operative. Two separate springs can be used stacked in series. It is best to preload the top spring.

For most of the expected shock loads, the efficiency will be that of a single helical spring. Efficiency for the entire deflection range is:

$$E = \frac{F_1 x_m + F_m x_2}{2F_m x_2} \qquad (3)$$





6 Damped linear springs

Commercial shock-absorbers frequently include high damping in the system to improve the shock response of the system. This also improves shock efficiency. Assuming initial conditions of $x = 0$ and $dx/dt = V_o$, at $t = 0$, then

$$M\frac{d^2x}{dt^2} + c\frac{dx}{dt} + kx = 0$$

This leads to the following deflection and force equations:

$$x = V_0 e^{-\frac{ct}{2M}} \frac{\sin \omega t}{\omega} \qquad (4)$$

and

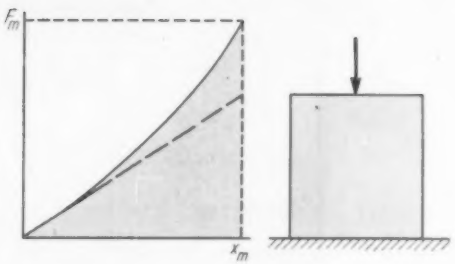
$$F = V_0 e^{-\frac{ct}{2M}} \left[\left(M\omega - \frac{c^2}{4M\omega}\right)\sin \omega t + c \cos \omega t\right] \qquad (5)$$

where

$$\omega = \sqrt{\frac{k}{M} - \frac{c^2}{4M^2}}$$

A load-deflection curve can be computed from these equations by using ωt as a parameter. The efficiency can be determined from Eq (1), (4) and (5) and is a function of the critical damping ratio c/c_c where $c_c = \sqrt{4Mk}$ (see chart A). In general, highly damped materials such as rubber give values of c/c_c up to 0.25. For higher values, special devices such as dashpots are more practical.

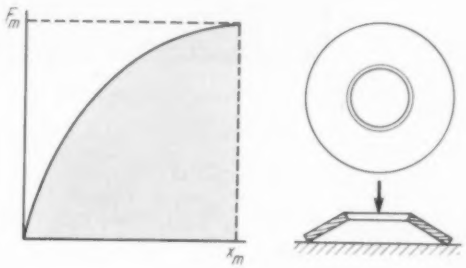
The maximum force in the above load-deflection curve does not occur at the maximum deflection. The ratio of the maximum force to the force at maximum deflection is also a function of the critical damping ratio and can be used to determine the required spring rate. This ratio is also plotted against efficiency in Chart A.

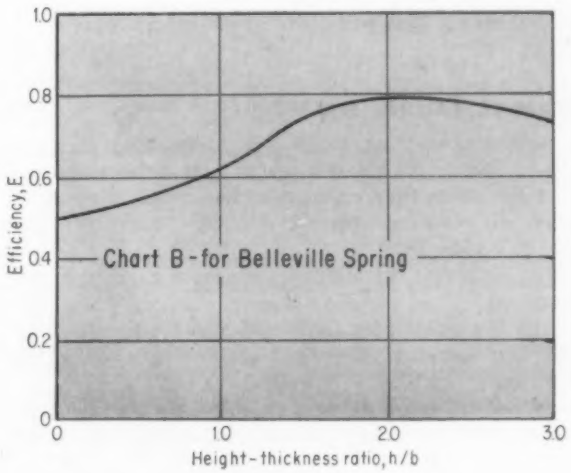


7 Nonlinear shock absorbers—increasing-rate types

Load-deflection characteristics of most resilient materials, such as rubber and plastics, and most devices employed in shock- and vibration-isolation, are linear for a small portion of the curve, then increase exponentially.

Efficiency for such materials and devices is less than for a simple linear spring. Their key advantage, however, is their high inherent damping which provides an additional force under dynamic conditions. This force tends to fill in the unshaded portion of the maximum force-deflection rectangle in the graph.





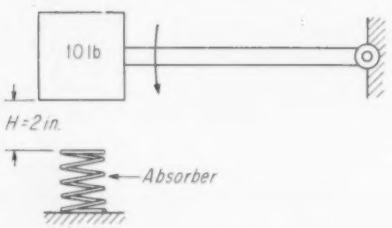
8 Nonlinear springs—decreasing-rate types

Belleville conical-disk springs have rates which decrease with deflection. A graph of efficiency in terms of disk thickness and height has been computed and plotted in Chart B (method of computation will be discussed in one of the sample problems). This type of spring finds use where large forces and small deflections are encountered.

continued, next page

COMPARISON OF ENERGY-ABSORBING SYSTEMS

Type	Range of Efficiency	Example	Efficiency Equation	Typical Applications
LINEAR SPRING	½	Helical metal spring	$E = ½$	Flexible limit stop; applications requiring absorber having low cost and simple design.
PRELOADED SPRING	$½ < E < 1$	Restrained helical spring	$E = \frac{F_1 + F_2}{2F_2}$	
CONSTANT FORCE DEVICE	1	Hydraulic shock absorber	$E = 1$	Recoil absorber for heavy gun; applications requiring large amounts of energy to be absorbed.
DAMPED SPRING	$½ < E < 1$	Rubber mount	$E = f(c/c_c)$, see Chart A	Equipment isolators; applications requiring good vibration isolation.
NONLINEAR SPRING	$0 < E < 1$	Belleville spring	$E = f(h/t)$, see Chart B	Applications requiring high loads and small deflections.
MULTI RATE SPRINGS	$0 < E < 1$	Dual-rate helical spring, increasing rate	$E = \frac{½F_1 x - F_2 x_2}{F_2 x}$	Shock absorbers in applications requiring low forces from most of the expected shocks and adequate protection for occasional higher shocks.



EXAMPLE—FALLING MASS

A device weighing 10 lb is suported by a pivot, as shown above. An absorber placed 2 in. below must prevent the device from experiencing more than 8 g's of acceleration when the support is released. Deflection is limited to 0.5 in.

(A) Calculate the minimum efficiency required by the absorber.

(B) If a preloaded spring is chosen as the absorber type, calculate the required preload and spring rate for this efficiency.

(C) If a damped spring is chosen as the absorber type, calculate the minimum value of c/c_c and the spring rate it would require.

Solution:

(A) Potential energy of the device is equal to that of the shock absorber at its maximum deflection. For a drop height of $H = 2$ in., the relationship becomes:

$$(H + x)\,W = EFx = EWGx$$

$$E = \frac{H + x}{Gx} = \frac{2 + 0.5}{8\,(0.5)} = 0.625$$

• This shows that an unpreloaded helical spring cannot meet these conditions.

(B) Maximum force in this case is: $F_m = W\,G = (8)(10) = 80$ lb. Thus, the required preload from Eq (2) is:

$$F_1 = F_m\,(2E - 1) = 80\,[(2)\,(0.625) - 1)] = 20 \text{ lb}$$

The spring constant is:

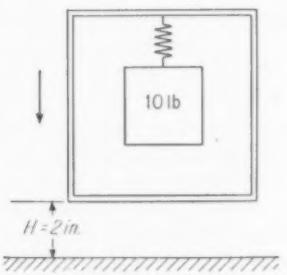
$$(F_m - F_1)/x_m = (80 - 20)/0.5 = 120 \text{ lb/in.}$$

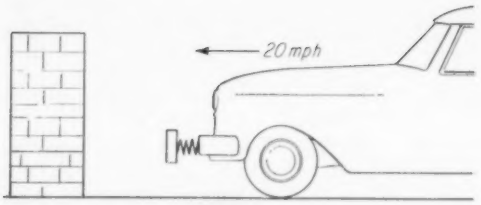
(C) From Chart A, a value for c/c_c of 0.07 provides the required efficiency. From the same chart the force ratio is essentially unity, hence the force maximum deflection is 80 lb, and the spring rate is this value divided by the total deflection, or $80/0.5 = 160$ lb/in.

A dropped shipping container (shown below) will also require a spring with an efficiency of 0.625. The 10-lb mass acts as a preload to provide an efficiency of

$$\frac{10 + 80}{2\,(80)} = 0.562$$

This does not meet the requirements and other measures must be taken.





EXAMPLE—LINEAR IMPACT

A vehicle slams into a solid wall at 20 mph (29.2 ft/sec).

(A) What minimum deflection does a bumper attached to the front require if it must limit the maximum acceleration of the vehicle to 20 g's?

(B) For this deflection, what acceleration in g's would the vehicle experience if a simple helical spring ($E = 0.5$) were used for the bumper?

Solution:

(A) The kinetic energy of the vehicle to be absorbed by the bumper is:

$$\frac{W\,V^2}{2g} = EFx = EWGx$$

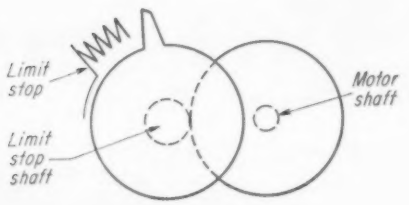
$$x = \frac{V^2}{2EgG}$$

The minimum deflection under the given conditions will occur when $E = 1$; hence

$$x = \frac{29.2^2}{(2)\,(20)\,(32.2)} = 0.66 \text{ ft or } 8 \text{ in.}$$

• This shows that any system used here must deflect at least 8 in.

(B) $$G = \frac{V^2}{2Egx} = \frac{(29.2)^2}{(0.5)\,(2)\,(32.2)\,(0.66)} = 40\ g\text{'s}$$



EXAMPLE—TORSIONAL IMPACT

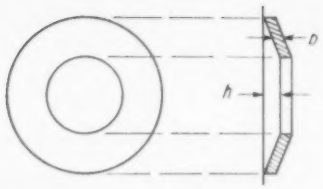
A flexible limit stop having a maximum deflection of 40° is to protect a gear train from the inertia of the driving motor. The motor has a moment of inertia of $I = 0.01$ in.-lb-sec^2 and a maximum speed of $n = 1000$ rpm. The torque strength of the weakest gear referred to the limit stop shaft is $T = 100$ in.-lb. Assuming that the motor drives a negligible instrument load and the motor power is shut off just before contact is made with the limit stop, what must the minimum efficiency of the limit stop be?

Solution:

The kinetic energy of the motor must be absorbed by the change in potential energy of the limit stop.

$$ET\theta = \tfrac{1}{2}In^2$$

$$E = \frac{In^2}{2T\theta} = \frac{(0.01)\,(2\pi)^2\,(1000)^2\,(360)}{(100)\,(40)\,(2\pi)\,(60)^2} = 0.78$$



EXAMPLE—EFFICIENCY OF BELLEVILLE SPRING

Relation between force and deflection for a Belleville spring having a thickness b and height h is given by:

$$F = Cx\,[(h - \tfrac{1}{2}x)\,(h - x)\,b + b^3]$$

where C is a constant determined by the material and dimensions of the spring. For a ratio $h/b = \sqrt{2}$, and assuming that the maximum deflection occurs when the spring is flattened ($x_m = h$), what is its efficiency?

Solution:

Solving for the deflection at which the maximum force occurs:

$$\frac{dF}{dx} = C\left[h^2\,b - 3hbx + \frac{3}{2}\,(x^2\,b) + b^3\right] = 0$$

$$x = h \pm \sqrt{\frac{h^2}{3} - \frac{2b^2}{3}}$$

For the value of $h/b = \sqrt{2}$: $x = h$. The maximum force is then $F_m = Cb^3h$. Thus $F_m x_m = Cb^3h^2$. The area under the force-deflection curve is obtained by integration:

$$\int_0^h F\,dx = C\int_0^h (h - \tfrac{1}{2}x)\,(h - x)\,x\,dx = Cb^3h^2\left[\frac{(h/b)^2}{8} + \frac{1}{2}\right]$$

The efficiency from Eq (1) is then:

$$E = \frac{(h/b)^2}{8} + \frac{1}{2}$$

When $(h/b)^2 = 2$ the efficiency is: $E = 0.75$.

This value can be obtained directly from Chart B.

For REPRINT of above article, just check 602 on one of the Reader Service cards found in this issue.

EDITOR'S NOTE: Once you have selected the type of shock-absorbing system, volume, weight and dimensions of the spring become of more concern. For information on these problems see:

Your Guide to Springs that Store Energy Best, Nov 10 '58, p 71—Article gives equations for obtaining the volume efficiency of 11 spring materials, and the "form coefficient" of 15 spring shapes. Volume efficiency of a particular spring is then obtained by combining both values.

How Light a Spring for Absorbing Shock?, Feb 1 '60, p 49—Gives equations for quickly finding the lightest spring type to absorb impact.

Saving Space with the Liquid Spring, Aug 17 '59, p 54—A liquid spring can handle certain jobs in less space than can mechanical systems.

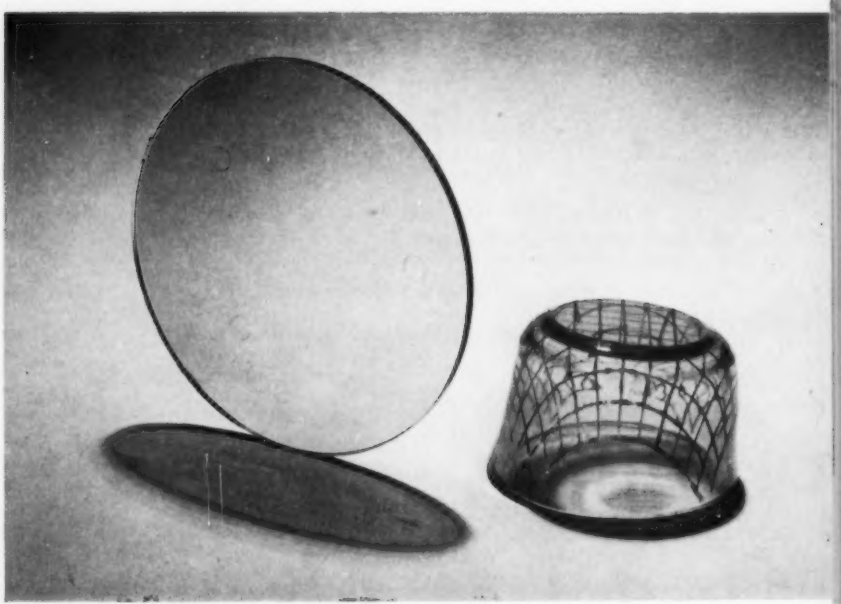
For more information on spring systems discussed in this article see:

New Constant-force Spring Systems, Mar 27 '61, p 54—Systems based on lever-and-spring and buckled-column principles.

Constant-force Compression Springs, Sep '54, p 129—Details of the helical spring with offset ends designed to buckle under load (illustrated in the present article).

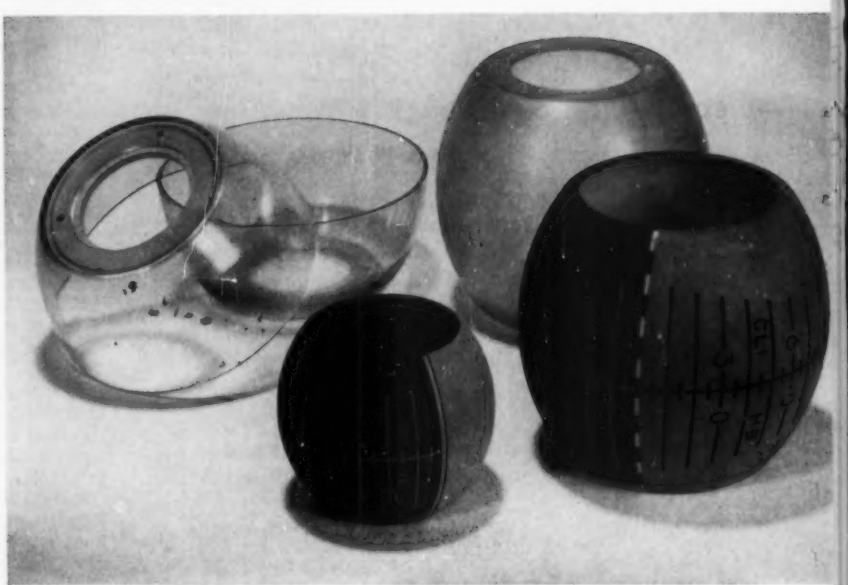
—Nicholas Chironis

DESIGN POLYCARBONATE PARTS THIS WAY



FOR SHOCK

Impact resistance and metal-like ductility are polycarbonate properties that allowed designing this deep-drawn part. Grid pattern painted on original blank (left) indicates elongation caused by the cold-forming operation.



FOR HEAT

Temperatures from —65 to 280 F, along with high humidity, must not distort these altitude-indicator dials beyond 0.005 in. of original dimension. Thermal testing at Lear Inc includes 1000 hr of continuous exposure to 250 F without change. The two halves are injection-molded by Monroe Industries for Lear's Instrument Div, then solvent-cemented and lathe-turned for accuracy. Three different paint colors are applied.

Lexan polycarbonate resins were introduced in these pages in an article that compared three new tough, rigid thermoplastics *(PE—Sep 29 '58)*. Since then, as applications have grown, the do's and don'ts of design have been established. Here they are.

C V LEUNIG, *technical service engineer*
Chemical Materials Dept
General Electric Co, Pittsfield, Mass

Polycarbonate resins are structural thermoplastics of extremely high resistance to impact and temperature. Such a combination of properties (Table I) presently commands a premium price for the plastic, $1.30 per lb. This offers the designer a double challenge: to make the most of this property profile while minimizing costs of finished parts. To meet this challenge, here is a design guide, based on experience since 1958 with GE's Lexan polycarbonate resins.

Load considerations

Polycarbonate resin can withstand high stresses in tension and compression, and also heavy impact stresses. Alternating or repetitive stresses, however, should be kept below the fatigue limit. Also, to prevent creep, steady-state loading should be limited to modest stress values. Recommended working stresses are summarized in Table II. A safety factor should be applied to these values as conditions dictate.

Compressive stresses can be tolerated readily up into the 8000 to 10,000-psi range. Loading may be continuous, intermittent, or applied as impact. In moist environments, or for parts immersed in liquids, the 8000-psi range is reasonable for steady-state compressive loads. Creep under compressive loads at room temperature will become a factor at about 2000 psi.

Tensile stresses tend to have widely different effects, depending on the environment. In a "good" environment tensile stresses in the order of 8000 psi will not break a part or cause it to yield beyond its elastic deformation. A "good" environment is ordinary room temperature and humidity, with no solvents or solvent vapors. Considerably lower tensile stresses should be employed whenever the part will be exposed to high humidity at high temperatures, to hot water, or to solvents, because stress-cracking may occur.

Environmental stress-cracking, also known as crazing (observed in polystyrene, methylmethacrylate, polyethy-

continued, next page

I—PROPERTIES OF LEXAN MOLDINGS AT ROOM TEMPERATURE

Property	Typical Value
MECHANICAL	
Tensile strength, psi	9000 to 10,500
Tensile yield point, psi	8000 to 9000
Flexural strength, psi	11,000 to 13,000
Compressive strength, psi	11,000
Shear strength, psi	9200
Shear-yield point, psi	5400
Modulus of rigidity	116,000
Tensile modulus, psi	320,000
Compressive modulus, psi	240,000
Flexural modulus, psi	375,000
Tensile elongation, %	60 to 100
Poisson's ratio	0.38
Rockwell hardness	M70, R118
Shore durometer "D"	82
Abrasion resistance, (Tabor Abraser with CS-17 wheel, 1000 g load), mg/1000 cycles	7 to 11
Izod impact strength, (⅛ in. bar) ft-lb/in.	12 to 16
Tensile impact, ft-lb/cu in.	600 to 900
Endurance limit (1800 cps), psi	2000
PHYSICAL	
Specific gravity	1.20
Odor	None
Taste	None
Water absorption (24-hr immersion), %	0.35
Color, unpigmented	Light amber
Light transmission (⅛-in. thick), %	65 to 75
Refractive index at 25 C	1.586
THERMAL	
Heat-distortion temperature (264 psi), °F	270 to 280
Heat-distortion temperature (66 psi), °F	270 to 280
Thermal conductivity, btu/hr/sq ft/°F per in.	1.33
Coeff. of thermal expansion, in./in./°F	3.9
Brittleness temperature, °F	−215
Flammability	Self-exting.
Recommended temp. (in hot water or continuous high humidity), °F	140

II—RECOMMENDED WORKING STRESSES

Service and Loading Conditions	Maximum Recommended Working Stresses, psi: Tensile	Compression
Steady load, room temperature, air	8000	9000
Steady load, 125 F, air	7000	7000
Steady load, 212 F, air	5000	5000
Occasional impact load	8500	9500
Steady load, room temperature, moisture, vapors	5000*	8000
Steady load, elevated temperatures, moisture	2000*	7000
Oscillation or vibration	1000	1000

* Tests under conditions of use are advisable to avoid stress cracking.

III—TAPER FOR DIFFERENT DRAFT ANGLES

(all values in inches)

Depth, In.	Draft Angle, deg					
	1/4	1/2	1	2	3	4
1	0.0044	0.0087	0.0175	0.0349	0.0524	0.0699
2	0.0088	0.0174	0.0350	0.0698	0.1048	0.1398
3	0.0132	0.0261	0.0525	0.1047	0.1572	0.2097
4	0.0176	0.0348	0.0700	0.1396	0.2096	0.2796
5	0.0220	0.0435	0.0875	0.1745	0.2620	0.3495
6	0.0264	0.0522	0.1050	0.2094	0.3144	0.4194
7	0.0308	0.0609	0.1225	0.2443	0.3668	0.4893
8	0.0352	0.0696	0.1400	0.2792	0.4192	0.5592
9	0.0396	0.0783	0.1575	0.3141	0.4716	0.6291
10	0.0440	0.0870	0.1750	0.3490	0.5240	0.6990

lene, polypropylene and most rigid thermoplastics) will occur when resin surfaces stressed in tension to some limiting point (critical elongation) are exposed to certain liquids and vapors. Critical elongation is the strain at which crazing is first observed while exposing the surface to the environment as stress increases. Critical elongation varies with environment. For carbon tetrachloride and acetone, two of the most active crazing liquids, the values are 0.5% and 0.35%, respectively. Hexane at room temperature can be tolerated below tensile strains of 0.8%. Crazing can also be caused by a combination of tensile stress, heat and moisture. Compressive stresses, however, are no problem. A temperature of 140 to 160 F is recommended as the top limit.

Creep, or cold flow will not occur until tensile stresses rise above approximately one-fifth the breaking stress. To maintain maximum dimensional stability, steady-state tensile stresses should not exceed the 1400 to 2000-psi range at room temperature. In the 100 to 200-F range, stresses should be reduced by about one-half to keep the same performance in creep.

Fatigue-endurance limit at room temperature is about 2000 psi at 1800 cpm. Lexan resin thus does not compare favorably with some other plastics for parts subjected to millions of repetitive heavy-load applications. However, it stands up under hundreds or thousands of suddenly applied loadings better than most other materials.

Gear applications illustrate this. Lexan gears withstand tremendous shock loads. They run well at moderate speeds. Yet high-speed Lexan gears running continuously for long periods have exhibited fatigue failures. Where to draw the line between the two types of applications must be decided by actual trials.

Standard Izod impact tests with ⅛-in. notched test bars yield values from 8 to 11 times greater than the value for acetal resin, nylon, or polypropylene; and 3 to 4 times the value for ABS copolymers. Much depends on section thickness, however.

Test values for polycarbonate bars change abruptly when certain thickness is surpassed. This transition point, termed "critical thickness," occurs between 0.140 in. and 0.160 in. for Lexan. Below this thickness, the resin elongates tremendously. Very high impact is required before failure—a ductile break—results. In contrast, thick specimens fail with a clean break at much lower impact. Typical Izod values for this type fracture are in the range of 2 to 3 ft-lb/in. of notch.

Heat aging reduces critical thickness progressively. On continued heating, a point is reached where a 0.125-in. specimen displays a brittle fracture. On the other hand, critical thickness is greater with cold working. For example, speciments cold-rolled down to 0.300 in. thick from 0.500 in. displayed ductile fractures and notched Izod impact values of 16 ft-lb/in. Cold working retards, but does not entirely prevent reduction of impact strength from heat aging.

Shapes and proportions

The following design rules for shapes and proportions will yield more significant benefits with polycarbonate resin than with many other materials, because the properties of the resin tend to put it in critical roles:

Fillets on internal corners assist flow during molding, and reduce stress concentrations when the part is loaded in service. Smooth curves on external corners also assist flow during molding. As a working rule, give internal corners ⅛-in. radii minimum. This may be reduced for miniature parts not highly stressed. A fillet radius equal to half the adjacent section thickness may be employed in such situations. Larger fillet radii, as generous as design function and styling permit, will pay dividends in performance.

Internal fillets should be kept in mind in machined parts as well as in molded surfaces. Machined slots, grooves, counterbores, steps, keyways, etc. should not have sharp internal corners. Specify as large a fillet as possible at such locations. External radii of cases and vessels can advantageously be made equal to the internal fillet radii plus section thickness, giving a smoothly rounded section of constant thickness. Smaller external radii are permissible.

Section thicknesses should be uniform; transitions from thick to thin should be tapered smoothly. Keep in mind how the molded part will be gated, or how it can be gated. Make provision for resin flow from thick sections to thin sections as the mold cavity is filled. Filling thick sections via thin ones can yield poorly molded parts with voids and sinks, or with excessive locked-in strains.

Maximum section thicknesses for injection moldings will be about ⅜ in. in most practical cases. Thicker sections can be produced. It is possible to mold a resin "insert" into a resin part to produce a sound thick section. Minimum section thickness as low as about 1/32-in. is common for miniature parts. Thinner pieces, down to 0.020 in. wall, can be molded. For most ordinary applications, 0.050-in. is a good working minimum.

Draft should permit easy removal of a part from the mold. It is common practice to allow ¼ to 2° per in. for draft, per side. The larger value should be allowed, if possible, on internal walls when the draw is relatively deep and where shapes are complex. Values of taper for different draft angles can be found in Table III.

Machining versus molding will be a choice in some cases, especially if the part requires deep, small-diameter holes. It is usually more satisfactory to drill such holes than to maintain relatively fragile core pins in good

condition and alignment. Threads can be tapped in the same setup as the drilling operation if required. Machining may be justified for added precision; but usually parts can be molded accurately enough to make this unnecessary. Machining is the most common way of producing undercuts, and is used to remove traces of gates and sprues.

Ribbing large flat surfaces for strength and rigidity is good practice. It saves material, and assists resin flow. Rib thickness should ideally be about one-half to three-quarters the adjacent section thickness. Excessively heavy ribs may cause bubbles or sinks during molding. Use many shallow ribs rather than a few very deep ones. Sometimes it is better to corrugate or offset a surface instead of using ribs for stiffness and support. Another way is to give the panel a slight dome shape; a fairly flat conical shape may serve the same purpose more economically if the area is circular.

Fabrication methods

Lexan polycarbonate resins can be fabricated and finished by a wide variety of methods. The discussion which follows provides the information required to select: the most economical method of production; best way to achieve color and decoration; the design features for reliable performance.

Injection molding is the key process. The more costly compression or transfer methods will occasionally be useful. Machining, cold forming, and welding can be used to supplement molding in special cases and yield the same cost savings in Lexan resins as they do in metals. Polycarbonates also can be blow-molded.

Compression- and transfer-molding techniques are entirely feasible if adequate temperatures can be attained. They are rarely employed in production work because of the costly slow time cycles entailed. If a piece of nearly strain-free material is needed, compression molding is usually the best way to produce it. However, compression-molded parts are generally not as tough as those extruded or injection-molded. A prototype model is often made in a simple compression-molding die. Prototypes may also be machined from extruded stock shapes or from a compression-molded block.

Glass-fiber-filled molding compounds are used when the part must have greater stiffness and strength than the resin itself affords. Flexural strength is 20,000 to 30,000 psi and is relatively independent of heat, aging, or moist environments. Flexural modulus is over 1 million psi (for 40% glass fiber content). Impact strength does not display the dependence on specimen thickness that is observed in unfilled resin. Values for the notched Izod test range from 3 to 6 ft-lb/in. of notch.

Finished surface is studded with small bundles of glass fiber. Design rules for it are the same as those for the standard resin. Conventional injection-molding presses are used.

Films of resin can be produced by extrusion or by casting. Film from 20 mils down to less than 1 mil thick can be given the same design treatments as heavier sheet. It can be creased cold to make box-like structures. Properties are essentially identical to those moldings or extrusions with thick sections.

Extruded shapes are generally not advantageous unless a relatively long piece is actually desired. Small parts should not be designed to be sliced from an extrusion; instead, design for separate injection-molded parts. Complicated profiles are often difficult to produce to tight tolerances and generally will not be as accurate as moldings. Extruded shapes can be bent either hot or cold; tubes can be flared to make fasteners. Rod stock up to $\frac{1}{8}$-in. diameter can be cold-headed with the same techniques common for metal rivets. Extrusions may be welded, solvent-cemented, joined by adhesives, or assembled with mechanical fastenings. Tubing can be joined with pipe threads.

Cold-working techniques, not normally possible with thermoplastics, can be specified with polycarbonates. These include: hammer forging, coining, stamping, drawing, and die-bending. Lexan resin is not as ductile as brass, but the same types of equipment and tools can be used as those employed with steel, brass or aluminum, if allowance is made for 5 to 6% springback. While such techniques are practical, more development work remains to be done. Limits of the cold-forming process have not been set precisely. A safe approach is to start with a design that can be produced satisfactorily in half-hard sheet brass of the same thickness. If tooling for brass is available, use these dies to make parts for evaluation.

Sheet stock can be hot-formed by conventional vacuum-forming processes. Unnecessarily deep draws should be avoided in design; but if a severe draw is called for, allowing generous radii and taper will help. Relatively reavy resin sheet can be hot-creased in a process analogous to brake-bending metal. A heated blade with a V-shape edge is first pressed against the sheet long enough to melt a groove in the sheet. Then, the blade is removed and the sheet is creased toward the melted groove. As the plastic solidifies after bending, it forms a reasonably smooth internal fillet.

Laminates can be made with glass cloth in conventional fashion, a useful technique whenever greater stiffness and much higher, more reliable long-term tensile strength is desired in a flat part than the resin itself affords. Mechanical properties of the glass laminates depend largely on the properties of the glass. Tensile strength increases four- to six-fold. Typical flexural strengths range from 30,000 to 60,000 spi. Flexural modulus will be in the order of 1 million psi. Impact properties, as they depend on the glass, do not display the sensitivity to critical thickness that the pure resin does. All breaks are brittle. Typical notched Izod impact values range around 4 ft-lb/in.

Heat-distortion temperature may run 10 to 30 deg F higher than that of unreinforced resin. Effects of heat aging and of environmental tensile-stress combinations should be checked for individual applications because data so far is incomplete. Electrical properties are close to those of the pure resin, as is resistance to chemicals.

Color imposes few limits on design, though experts in coloring Lexan should be consulted. The resin is supplied in a variety of opaque, transparent, and translucent hues. In addition, it may be painted and lacquered, hot-stamped with pigmented leaf, vacuum-metallized, and printed by silk screen. Multicolor molding is possible, as is dyeing, although the latter process is a proprietary one. Pigmented resins will not change at use temperatures.

Surface coatings can provide identification, establish the

desired level of surface gloss, close pinholes or hide surface blemishes and stains imparted by mold finish, and give special effects such as luminescence or mirror surfaces. With the use of suitable masks, coloring selected areas, etc., a wide variety of design effects can be achieved with coatings. For example, backlighted dials can be numbered or lettered, giving a striking 3-D effect when the transparent part is colored on the far side.

The resin itself may serve as a coating material. The most common method is solution-coating where the resin, dissolved in a suitable solvent, is applied by painting, dipping, or spraying. Adhesion is good enough for the liquid resin to work as an adhesive. Fluidized-bed techniques may be used to coat such materials as metals that can stand high temperatures.

Two main precautions when polycarbonate resin is employed primarily for its transparency are: (1) Avoid the combination of high tensile stress with moisture or chemical environments and elevated temperature; this causes mild hazing as a result of stress-cracking; (2) avoid exposure to severe radiation in the ultraviolet range. For sunlight exposure in most parts of the temperate zones, this will not be a problem. Whenever a reasonable amount of light transmission is needed, but not necessarily crystal clarity—as in the lens for an indicator lamp—limitations on both stress and ultraviolet radiation can be relaxed.

The joining methods

Parts may be joined to one another and to different materials by a variety of methods: Essentially permanent joints are created by solvent-cementing, hot-gas or other welding technique. Use of screws, bolts, clips, rivets, and other fasteners will permit disassembly.

Solvent-cementing through use of methylene chloride or ethylene dichloride can produce a joint nearly as strong as solid material. Nearly perfect fits are required, and it is necessary to keep the joint in a single plane. It is not feasible to join Lexan to other materials by this process.

Spin- and press-welding methods also produce strong, leaktight joints, as do conventional heat-sealing techniques. Strength of welded joints is not as high as that of the molded plastic: A good weld will take about 70 to 80% of the tensile-bending and impact-loading of adjacent sections. Minimum pressures should be utilized to avoid creation of localized strains.

Adhesives of many types—epoxies, styrene-polyesters, polyurethanes, etc.—can be used where speed and economy, rather than strength, are primary needs. They also prove useful for bonding the resin to other materials.

Mechanical fasteners present fewer difficulties, and should be employed whenever design requirements permit. Standard procedures for fastening soft metals and other plastics—inserts, bosses, rivets and similar pasts—suffice. No special precautions are needed. Lexan resin can be used for bolts or rivets, the latter useful up to $\frac{1}{8}$ in. diameter. Eyelets can be made by cold-flaring tubing.

Threaded fasteners necessarily create stress concentrations. As long as loads introduced by the fasteners are low compared to those carried by the part, environmental stress-cracking will not be a problem. Overtightening however, can set up high bending or tensile stresses and create trouble. Threaded bushings help carry the tightening load. If the insert is located near the edge of a molding, the supporting material on the outside should be at least as thick as the insert's diameter.

Self-tapping screws can be used either in cored or drilled holes. Keep in mind that when these screws form their threads in Lexan resin, they can also set up extremely high localized stresses. Therefore, the interrupted-thread tapping screws that actually cut into the plastic are preferred to those that force their way in. Use large holes so that only one-third to one-half of the screw-thread depth actually engages the plastic; it is better to let six or eight threads take a shallow bite than to gain the equivalent holding strength with two or three fully engaged threads.

The same general principle applies to tapped holes, but not so stringently. Threads can be tapped full depth or in the 75% range. The more threads that engage to carry the load, the less chance of localized overstressing. Fine-series threads are preferred. Helical inserts screwed into specially tapped holes to provide metal screw threads have been used very successfully. All specialized fasteners, such as spring clips, threaded ferrules for blind assembly, clip nuts, snap rings, flexible rolled-up pins, circumferential clamps, and similar fasteners can be used. Most of them avoid excessive loading, and improve compressive stresses.

EDITOR'S NOTE: Other recent articles on load-carrying plastics and how to design and fabricate with them include:

Filled TFE Teflon + Moly Disulfide, Mar 13 '61, p 76—Oriented glass fibers make Teflon strong, while the solid lubricant keeps it slippery.

Your Selection Guide to High-damping Materials, Apr 17, '61, p 44—Introduction to viscoelastic damping in plastic materials includes design data for over 50 candidates.

Blow Molding Goes Industrial, Jan 16 '61, p 50—If you need a thin-walled plastic part, take a look at the new ways a fast-growing process is being used.

Epoxy Parts Cast by Centrifugal Casting, May 23 '60, p 45—Article shows how to get precision plastic parts in quantities that aren't large enough to justify tooling costs of injection molding.

Designing High-impact Phenolic Molded Parts, Mar 7 '60, p 54—Adding glass-fiber reinforcement can make conventional phenolic a strong competitor to metals where shock loads are a problem. Article gives proper design criteria.

Which Process for Fiberglass-reinforced Plastic Molded Parts, Jan 11 '60, p 47—Have you side-stepped glass-reinforced plastics because of uncertainty about which process is which? If so, here's up-to-date guidance on the 7 key processes now available.

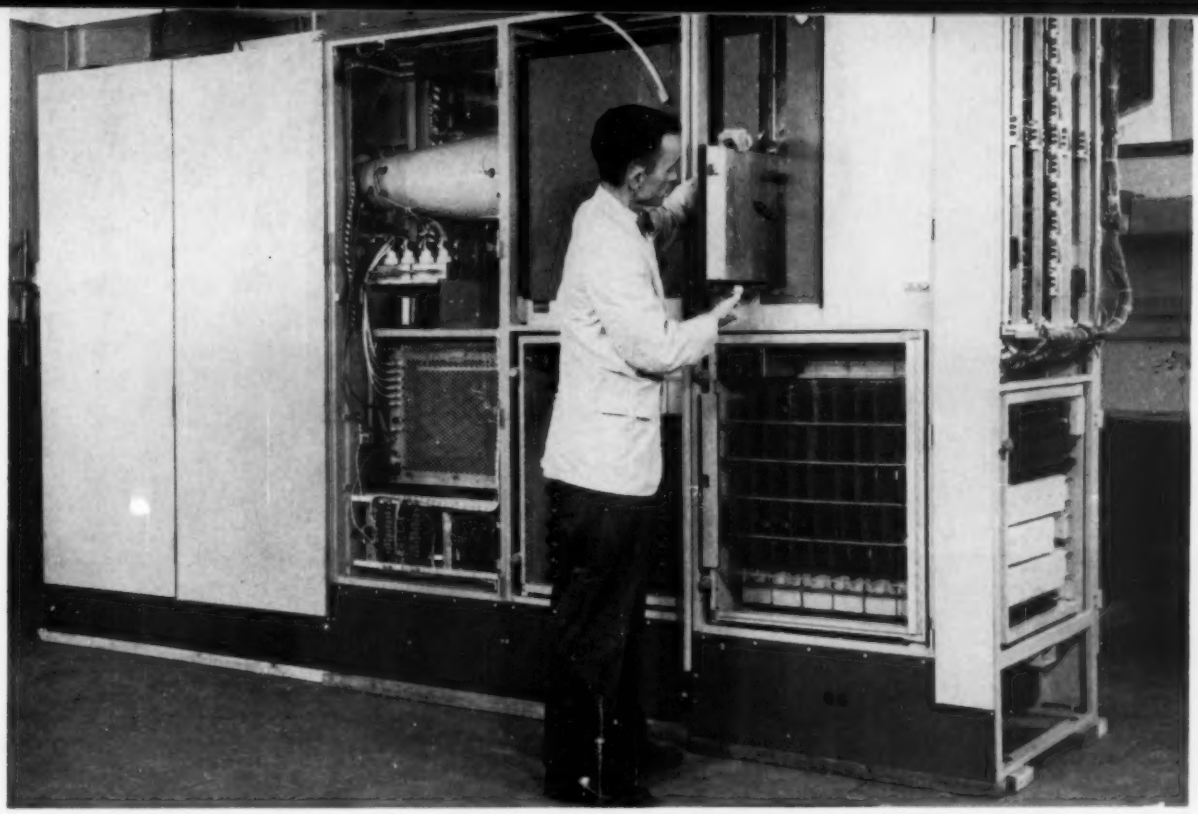
What Fillers Will Do for the Latest Teflon, Sep 28 '59, p 52—Like the older fluorocarbon resins, the copolymer type called Teflon 100X works better in some applications when it's reinforced. Here's latest design data on this new thermoplastic in filled form.

Better Linear Polyethylene Moldings, Mar 16 '59, p 55—A growing family of plastics is overcoming its "difficult-to-mold" reputation. Author's ground rules will simplify design.

Three New Tough, Rigid Thermoplastics: A Comparison, Sep 29 '58, p 36—Special report compares the properties of Lexan polycarbonate resin, Delrin acetal resin, and Pro-fax polypropylene resin.

Additives Strengthen Sintered Nylon, Sep 15 '58, p 86—Article shows how sintered nylon parts are made, cites materials available, tolerances possible, and gives the right approach to design.

—Ford Park



COMPLETE FLYING-SPOT MEMORY, including optical system with photographic storage, power supplies and circuits, installed in experimental telephone office, Morris, Ill. Capacity: 2.2 million bits, with random access to any portion in 5 microsec.

4 new random-access memories for DIGITAL WORK

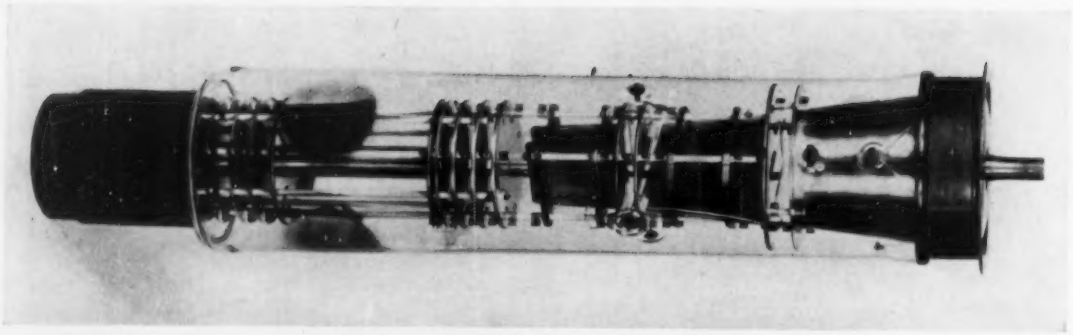
Our article, "Storage of Digital Information," June 20 '60, described existing types of digital storage systems. But in this fast-moving field, what looks good today may be obsolete tomorrow. To keep you up-to-date, here are four new systems, tried and tested, but not yet on the market.

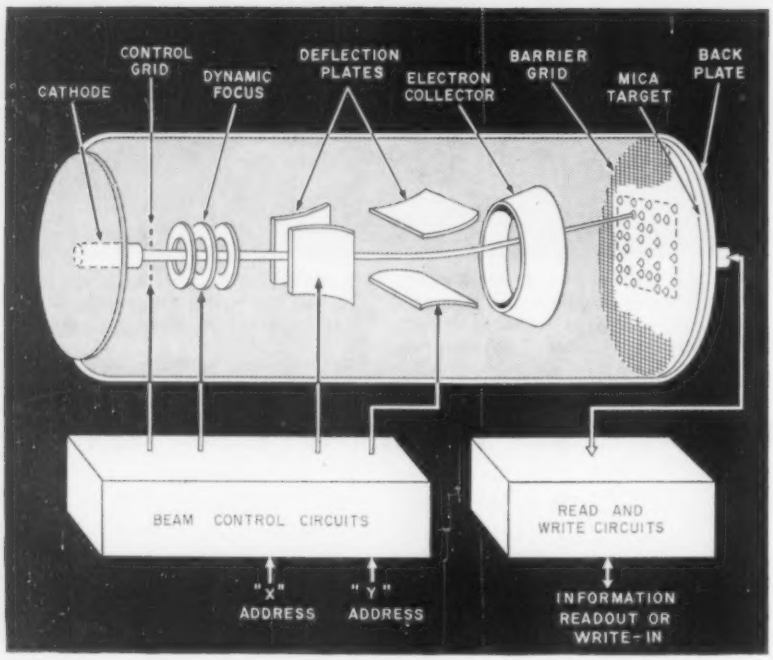
DONALD C KOEHLER, *staff engineer, Bell Telephone Laboratories, Whippany, NJ*

Stiff competition is facing today's magnetic-core memories. Not yet on the market, but already tried and tested, are four new memories of the random-access type. They aim not only at providing storage for high-speed, random-access computers but also for many lower speed, low-cost industrial-control applications. Most of their technical characteristics are as good as or better than what the magnetic-core type can offer. And their cost per bit will be lower. This means that when you need a high-speed storage system of medium to high capacity, and with access time counted in microseconds, you can now look forward to a much wider choice. Each of the four new ones is a different type: (1) barrier grid, (2) ferrite sheet, (3) flying spot, and (4) twistor.

The barrier-grid and ferrite-sheet types are called temporary memories because stored information can be readily changed, electrically, by the system which uses them. Though they operate somewhat differently, both have similiar advantages and limitations. For example, the write-in of the entire memory is accomplished in milliseconds. But because the information is destroyed as it is being read out, both types must contain special circuits to rewrite, bit by bit or word by word during the readout so that information can be preserved. And the barrier grid must continually rewrite once a second, even when nothing is being read out.

The flying spot and twistor types are semipermanent. They use electronics plus mechanical operations to change





BARRIER-GRID TYPE—tube stores up to 16,000 bits of temporary, electrically changeable information in the form of tiny electron charges on mica target. Presence of charge at any spot location signifies binary "1"; absence of charge signifies binary "0". Top row of simplified 8 x 8 array shown on target indicates binary number 10101001 (169 in decimal system).

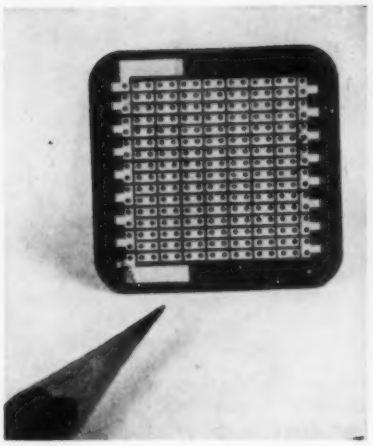
Write-in and readout are accomplished in similar manner—the memory receives *X*, *Y* coordinate address at which information is to be stored or read out, and the beam is deflected to this position on the mica target. If a binary "1" is to be written, the back plate is pulsed positive with respect to the barrier grid. This pulse holds the electrons from the beam onto the mica surface. If a binary "0" is to be written, no pulse is applied to the back plate. The electrons from the beam strike the surface and scatter away toward the electron collector, leaving no surface charge.

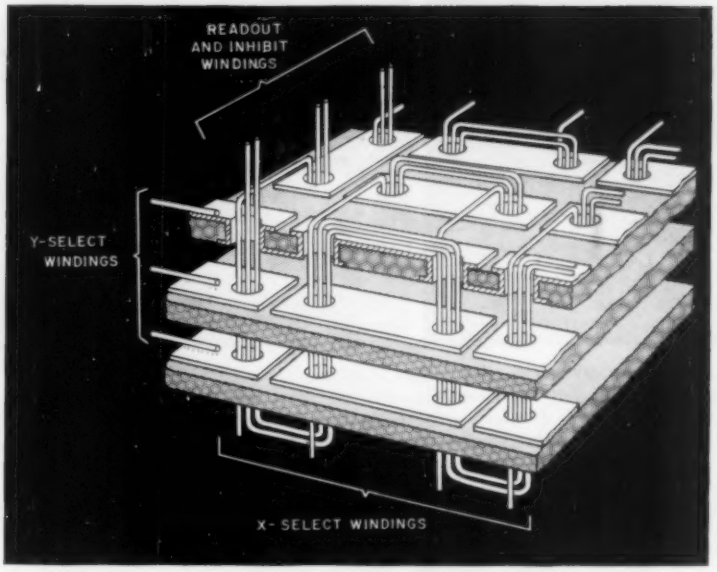
Readout differs from write-in only in that the target is not pulsed. Instead, the read circuits observe the target for presence or absence of charged spot. If a spot is charged, a pulse is generated, signifying a binary "1" was stored at that location; no pulse signifies a "0".

Because readout destroys the stored information, reducing each spot to a "0", the memory contains circuits which will, if required automatically rewrite the original information, spot by spot, as it is read out. Further, to prevent eventual deterioration of the stored charges by surface leakage, the circuits automatically read and rewrite (regenerate) every spot in the raster at 1-sec intervals. Total cycle time is only 2.5 microsec per spot, so regeneration of all stored information requires less than 5% of total time.

the stored information, which means that "information fill time" (the write-in) takes hours rather than milliseconds. However, they have two advantages over the barrier grid and the ferrite sheet. They cost less per bit, and because information cannot be changed electrically they are more reliable for long-term storage. Stray electrical pulses or power failure has no effect on them. Used in conjunction with the temporary memories in computers, the flying-spot and twistor types offer more reliability and lower cost wherever stored information must be of long duration, such as in computer programs, and in storage of constants or empirical data.

The accompanying table compares magnetic-core type with the four new ones. But be careful of dimensions when you compare storage densities: some units, because of their physical shape, are listed in bits per sq in.; others in bits per cu in. ■





FERRITE-SHEET TYPE—memory's thin ferrite plates contain a square array of 256 small holes. One-turn windings are threaded through the holes so the ferrite material surrounding each hole acts as a miniature magnetic core, and stores one bit of information. Plates are stacked vertically, storing 14,000 bits per cu in.

Holes in each plate are connected in rows by a printed conductor which passes through each hole, alternating from top to bottom of plate. This conductor forms the *Y*-select windings. The plates are stacked one above the other and three wires, consisting of the *X*-select, readout, and inhibit windings, are threaded through the holes, which are aligned vertically.

Simultaneous pulses on one *Y*-select and one *X*-select winding magnetize the ferrite surrounding each hole in the row which receives both pulses. This stores binary "1's" at that *X*, *Y* address. If binary "0's" are to be stored, the inhibit windings are pulsed at the same time. The opposite polarity of this pulse cancels out the *X*, *Y*-select pulse, leaving no magnetic charge.

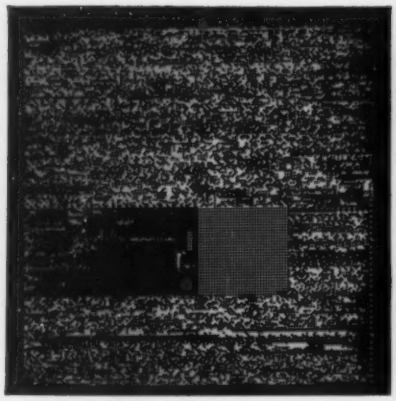
Readout is accomplished by sending reverse-direction pulses through the *X* and *Y* windings and observing whether induced voltage pulses (the 1's) appear on the readout windings. An induced voltage appears only if the selected hole has been magnetized during write-in.

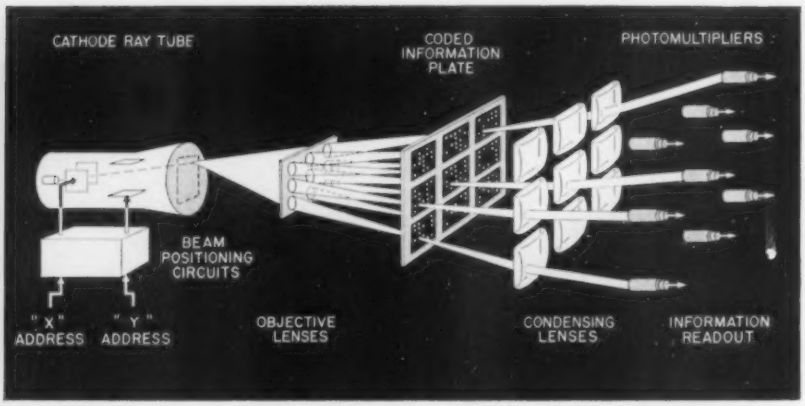
As with barrier-grid memory, readout destroys the information, and circuits must immediately rewrite if it is to be preserved. The magnetized ferrite is stable with time, however, and periodic regeneration is not needed.

continued, next page

CHARACTERISTICS OF RANDOM-ACCESS DIGITAL MEMORY SYSTEMS

Memory	Class of Information	Type of Readout	Kind of Storage	Access Time	Type of Access	Storage Capacity	Life of Memory Element	Information Fill Time	Typical Storage Density	Relative Cost/Bit
Barrier Grid	Temporary	Destroys Info	Electro-static	Micro-sec	Cathode Ray	Medium	Limited	Millisec	5000 bits/sq in.	Moderate
Ferrite Sheet	Temporary	Destroys Info	Magnetic	Micro-sec	Coordinate Windings	Medium	Indefinite	Millisec	14,000 bits/cu in.	Moderate
Flying Spot	Semi-permanent	Non-destructive	Photo-graphic	Micro-sec	Cathode Ray	Large	Indefinite	Hr.	18,000 bits/sq in.	Low
Twistor	Semi-permanent	Non-destructive	Magnetic	Micro-sec	Coordinate Windings	Large	Indefinite	Hr.	500 bits/cu in.	Low
Magnetic Core	Temporary	Destroys Info	Magnetic	Micro-sec	Coordinate Windings	Medium	Indefinite	Millisec	100 to 2000 bits/cu in.	High

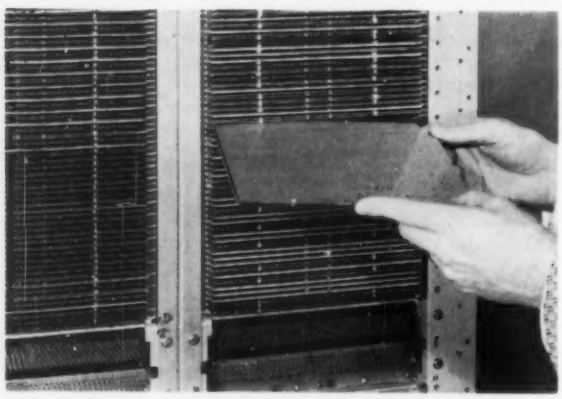


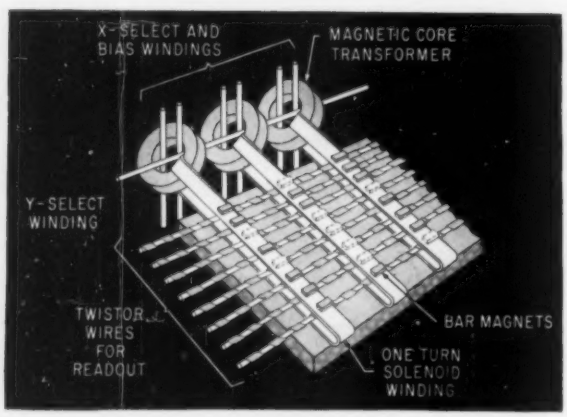


FLYING-SPOT MEMORY array here is intermediate capacity (capacities range from 4096 to 65,536 bits per array—this one contains 33,768). It is an exposed photographic glass plate measuring about 1.35 in. square; clear spots are about 0.006 in. diameter. Such memories store from 36,864 to 4.4 million bits in groups of 9 to 68 arrays. Each array indicates one digit of the binary numbers stored.

Diagram shows readout process: Cathode ray tube contains "flying spot" of light which is directed to a particular location by X and Y address circuits. For a specific address, the light is projected simultaneously through the lenses to corresponding X, Y locations on each array, which has previously been encoded with tiny clear or opaque areas. If light strikes a clear area it passes through the condensing lens onto a photomultiplier tube which signals a binary "1" readout. If the light strikes an opaque area on the array, it is blocked. The associated photomultiplier receives no signal, indicating a binary "0". Reading from left to right, top to bottom on the illustration, shows the binary number 001110100 (116 in decimal system).

Unlike barrier-grid or ferrite-sheet types, write-in is accomplished photographically. In order to change stored information, a new plate must be prepared. Unexposed, sensitized plates are inserted into the memory and exposure is made by the flying spot in combination with an automatic shuttering arrangement. The plates are then removed from the memory, photographically processed, then returned for use. Total storage process takes about 1½ hr and is semipermanent—no rewrite is needed.





TWISTOR MEMORY stores bits in tiny bar magnets—one bit per magnet—mounted on cards. Unit shown holds 512 cards, each containing 2816 magnets, for a total of 1,441,792 bits. Write-in is accomplished by removing cards and magnetizing or demagnetizing each bar magnet, using semiautomatic equipment. Storage is semipermanent—no rewrite needed.

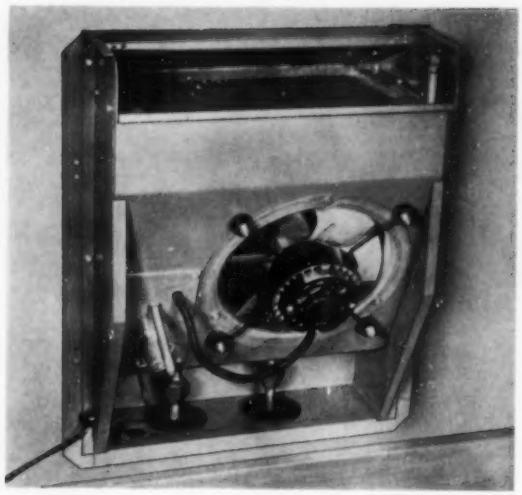
Simplified diagram shows magnets associated with one card plus Y-select, X-select, and bias windings running through magnetic core transformers. To read out, select an address and simultaneously pulse the appropriate X and Y windings. The core transformer at that address induces a current in its one-turn solenoid winding. This winding is magnetically coupled to the twistor wires by a magnetic tape wrapped around the wires. Wherever a demagnetized bar magnet (dotted lines) is located, a voltage pulse is induced in the twistor wire, signifying a binary "1". Where the magnet is magnetized (solid lines), flux changes in the tape are inhibited so that no magnetic coupling exists, hence no pulse appears on the twistor wire, and a binary "0" is indicated. When the left-hand core is selected as an X, Y address, binary number is 00101000 (40 in decimal system). In memory shown, 44 twistor wires are used for each readout, making possible numbers as high as 2^{44}, or about 17.6 trillion.

EDITOR'S NOTE: For more information on information storage, computers, and automatic control, see:

Design by Digital Computers, Apr 11 '60, p 43—How to choose and operate the new desk-size problem solvers. Includes discussion of the specialized vocabulary of information storage, input-output methods, and memory systems having special application to digital computers.

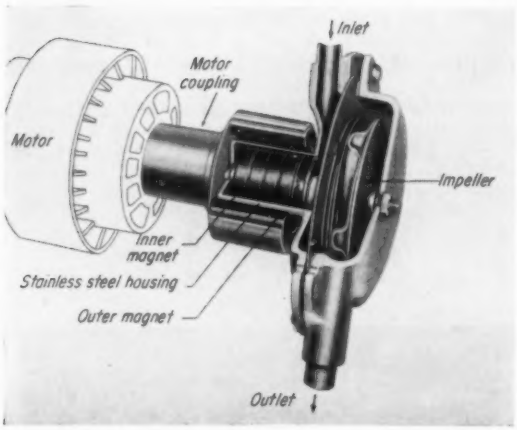
Storage of Digital Information, June 20 '60, p 68—Describes existing types of storage systems, how they operate, and where they are best suited. Also includes a bibliography of earlier articles that evaluate storage devices.

—Frank Hall



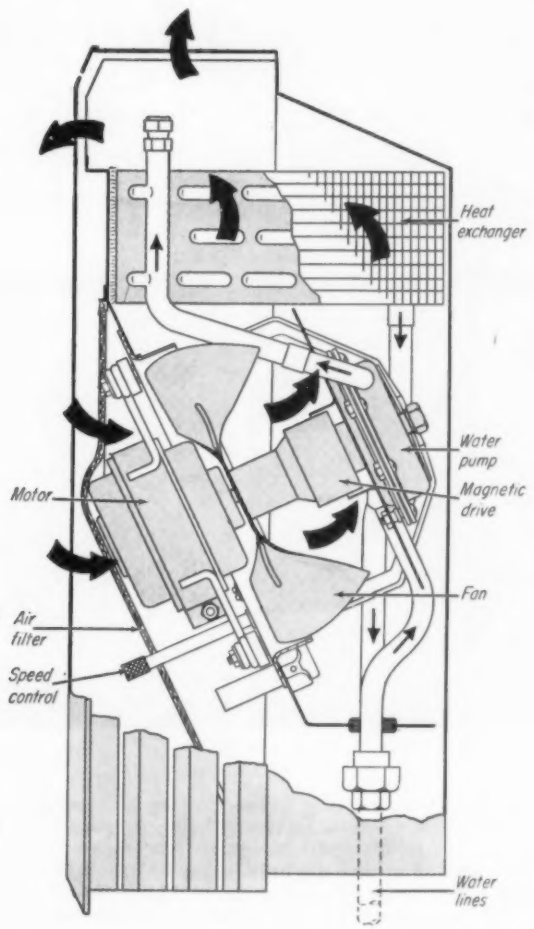
Magnetic Drive Eliminates Seal and Leaks

Fan and pump drives are combined to simplify a heat exchanger used as space-warmer. Heat output is controlled by adjusting motor speed.

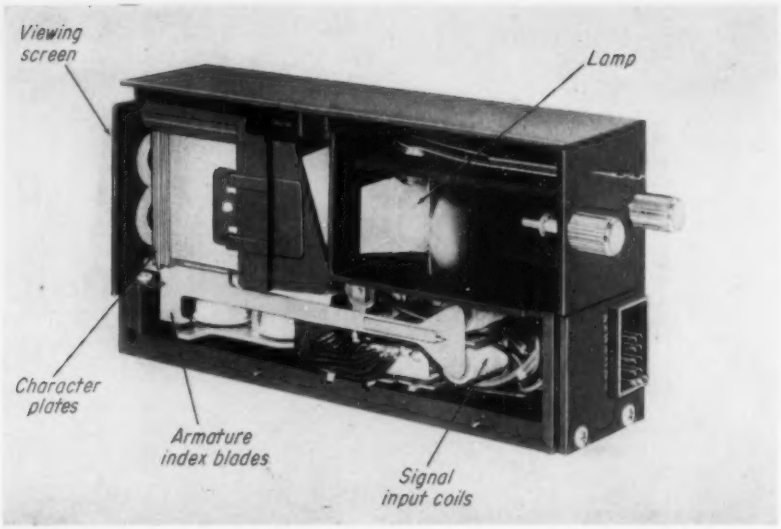


THE SAME MOTOR drives both the air-circulating fan and water-circulating pump. Fan is mounted on the magnetic drive coupling. Pump is completely encased in a stainless steel housing. Magnetic drive eliminates need for mechanical connection and shaft seals, reduces friction, and simplifies alignment. The 3-speed, shaded-pole motor has tapped windings for speed change, reduces power consumption at lower speeds because a rheostat is not used.

Adjustable temperature control provides three motor speeds. These speeds directly govern heat output because the same motor circulates both hot water and the warmed air. A thermostat starts and stops the motor to maintain the selected temperature.

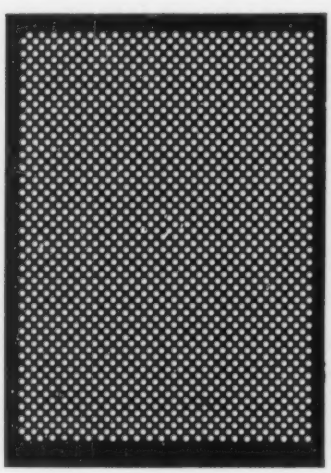


PS . . . The unit filters, warms and circulates air upward and outward to heat living spaces. A built-in control provides three motor (pump-fan) speeds. Output of heater rises from 5000 btu/hr when water enters at 120 F to 16,500 btu/hr at 220 F. Unit can be recessed in wall or mounted on free-standing frame. By Thermal Specialists Div of Iron Fireman Mfg Co, Cleveland.

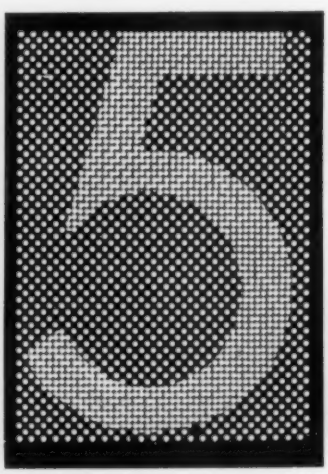


Shutter Action Translates Binary Code Directly

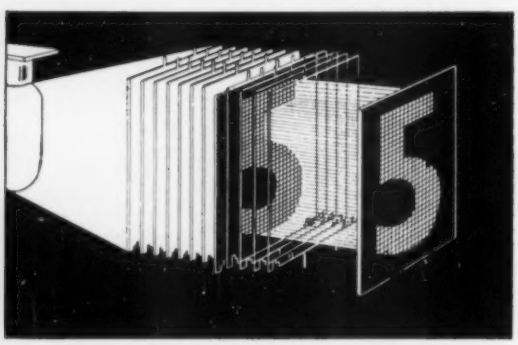
Digital readout converts coded input into visual display mechanically—no extra circuits needed. Character plates that block out unwanted light when dropped into position form the image on viewing screen.



A



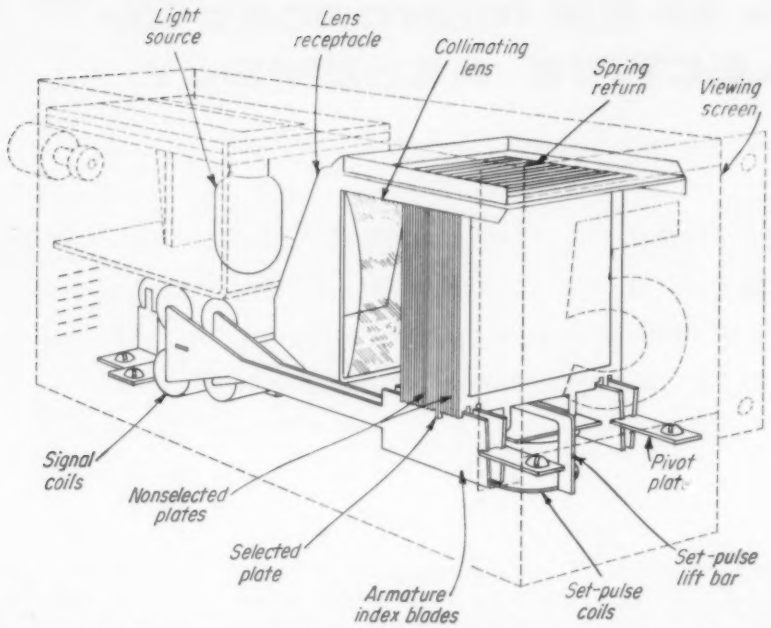
B



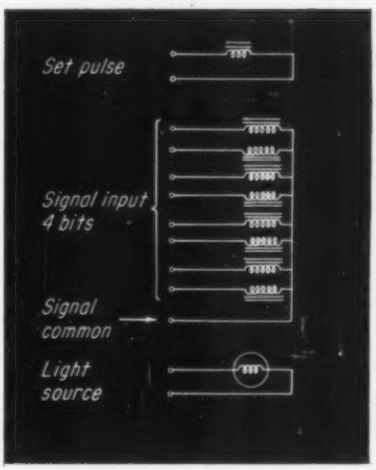
PLAIN PLATES are made by perforating a rectangular metal sheet with a regular pattern of holes, 256 per in. (A). Holes are 1/32 in. dia and 1/16 apart. If a stack of these plates is aligned so that the holes coincide, light will pass through. But if one plate is moved 1/32 in. out of line, light will be blocked out by the solid portions between the holes. Character plates (B) start out with the same pattern as plain plates, but have extra holes added to form the letter or number to be displayed. When one of these plates is moved out of line in a stack, the original holes are blocked out, but the extra holes in the character portion of the plate aren't; light passes through this area only, displaying an illuminated image of the desired character on the viewing screen.

In this model, ten character plates, 0 to 9, are used with a plain plate at front and rear. To keep the readout screen normally dark, the front plain plate is normally kept out of register with the rear plain plate. When a character plate is selected for display, the front plate is simultaneously shifted into register with the rear plate.

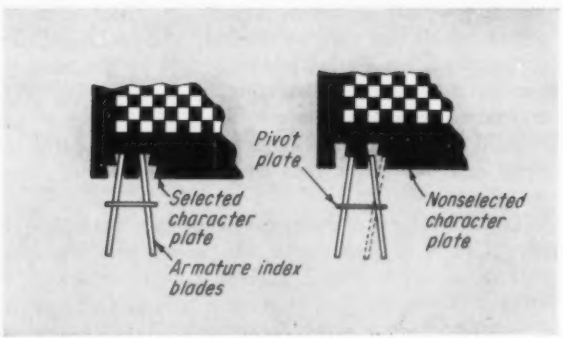
Here's how a character is displayed: In the bottom edge of each plate are four two-step notches. In some notches the deeper step is at the left; in others, at right. Each character has its own combination—"1" might have all



SINGLE-BULB SOURCE projects light through a collimating lens and the stack of perforated plates to the viewing screen. Plain plates at front and rear of stack are positioned to keep screen dark unless a specific character is selected. Set-pulse lift bar raises all character plates to permit armature index blades to move to the correct position. Spring-return then pushes the stack onto the blades. The character to be displayed drops further than the others, which are stopped short by the blades. System is well suited for binary input because blades are positioned either left or right.



READOUT CIRCUITS have four pairs of low-power (10 milliwatt) signal-input coils and two medium-power (2 watt) set-pulse coils. The set-pulse coils operate the bar that lifts the stack of plates, and the signal-input coils pivot the blades. The signal-input coils decode the proper character from the binary-coded decimal signal-inputs upon command from the set-pulse coils. Set-pulse duration is nominally 50 milliseconds. Additional signal inputs can then be accepted into the unit without disturbing the character on display.



deep steps at left, "2" might have two lefts and two rights, etc. (There are 16 possible combinations, but this unit needs only 11—one for each digit, one for a blank screen.)

Four index blades, pivoted left or right by solenoids, fit into these notches. When the signal for a given character is received, the blades pivot to the correct combination of left-right positions and the stack of plates is dropped onto them. All plates having one or more short steps in line with the blades will be stopped short. Only the desired character plate will have deep steps lined up with all four plates, so it will drop down out of line with the rest and be displayed on the viewing screen.

PS . . . Slide-plate digital readout accepts any BCD or teletype code up to six bits, does its own translating, and displays the proper character. No auxiliary translators, relays, or diodes are required. Readout operates in 50 millisec and can display up to 16 characters 1⅜ in. high. Digital readout is produced by Industrial Electronic Engineers Inc, N Hollywood, Calif.

how to set tolerances for SELECTIVE ASSEMBLY

Dividing production parts into matched sets is sometimes best way to achieve a precision fit. This graphical way to find size of each group is by an engineer at one of Argentina's largest manufacturers of automobile parts.

W HANKA
Automobile Factory, D.I.N.F.I.A.
Cordoba, Argentina

One way to get close-fitting parts is to hand-fit each assembly. The mass production version of this is selective assembly: measure the parts as they come off the line and divide them into groups according to size. The rest is simple—just assemble the group of smallest internal parts to the group of smallest external parts and the group of largest internal parts to the group of largest external parts, With this method you can improve tolerances by a factor of four or better.

But the system is not without its disadvantages. Obviously it's more costly and time-consuming than simply assembling parts as they come off the line. But weighing this against the cost of the tight tolerances necessary to get the same quality of fit often indicates that the economics are actually in favor of selective assembly. The most serious drawback remains the lack of interchangeability—an important factor when machines will be serviced in the field with parts drawn from stock.

In today's mass production, selective assembly is most often used for parts with an interference fit that are not intended to be disassembled after they have been pressed together at the factory. Here, interchangeability is not important. And here precision is critical—too much interference stresses parts unduly; too little, and they may not stay together.

Three conditions to meet

Design for selective assembly makes tolerancing more difficult. First you must decide how many groups to divide the parts into and then you must set upper and lower dimensional limits for each group. In choosing those group dimensions, you must satisfy three conditions:

1. Each group must contain roughly as many internal parts as external parts.

2. Range of fit, as improved by selective assembly, must be the same for all groups. Range of fit is the difference between maximum and minimum interference (or clearance) and is simply the sum of individual part tolerances.

3. Average interference (or clearance) must be the same for all groups (or as close as possible).

The dimensions of production parts can be distributed over the tolerance range in several ways. If distribution of dimensions is of the so-called "normal" type, the pattern will be the familiar bell-shaped curve indicating that there are few parts having either maximum or minimum dimension and many parts with an average dimension. Or the distribution can be "uniform" (also called rectangular). Here, there are an equal number of parts for each dimension within the tolerance range. But no matter what the pattern, if all parts have the same pattern the conditions above are easy to satisfy; simply divide the tolerance range for each part into equal segments. It makes no difference whether all parts have the same tolerance range; conditions 1, 2, and 3 will automatically be satisfied (see Fig 1).

But most production methods do not oblige us with such convenient distribution patterns. And more important, from the selective-assembly standpoint, distribution patterns for mating parts may not be the same (see Fig 2). In this case, dividing total tolerance into equal increments will no longer give the same number of parts (condition 1 unsatisfied). And dividing the curve into equal areas no longer gives equal tolerance of fit (condition 2 unsatisfied).

To resolve these difficulties, first measure a sample quantity of parts to find scatter of dimensions. Plot these data as shown in Fig 3. These curves are simply the integral of the distribution curve as it is normally plotted. Any horizontal line across this graph will satisfy condition 1: it cuts the curves at points marking the upper limit for equal numbers of internal and external parts (the lower limit, in this case, is the lower as-produced tolerance limit).

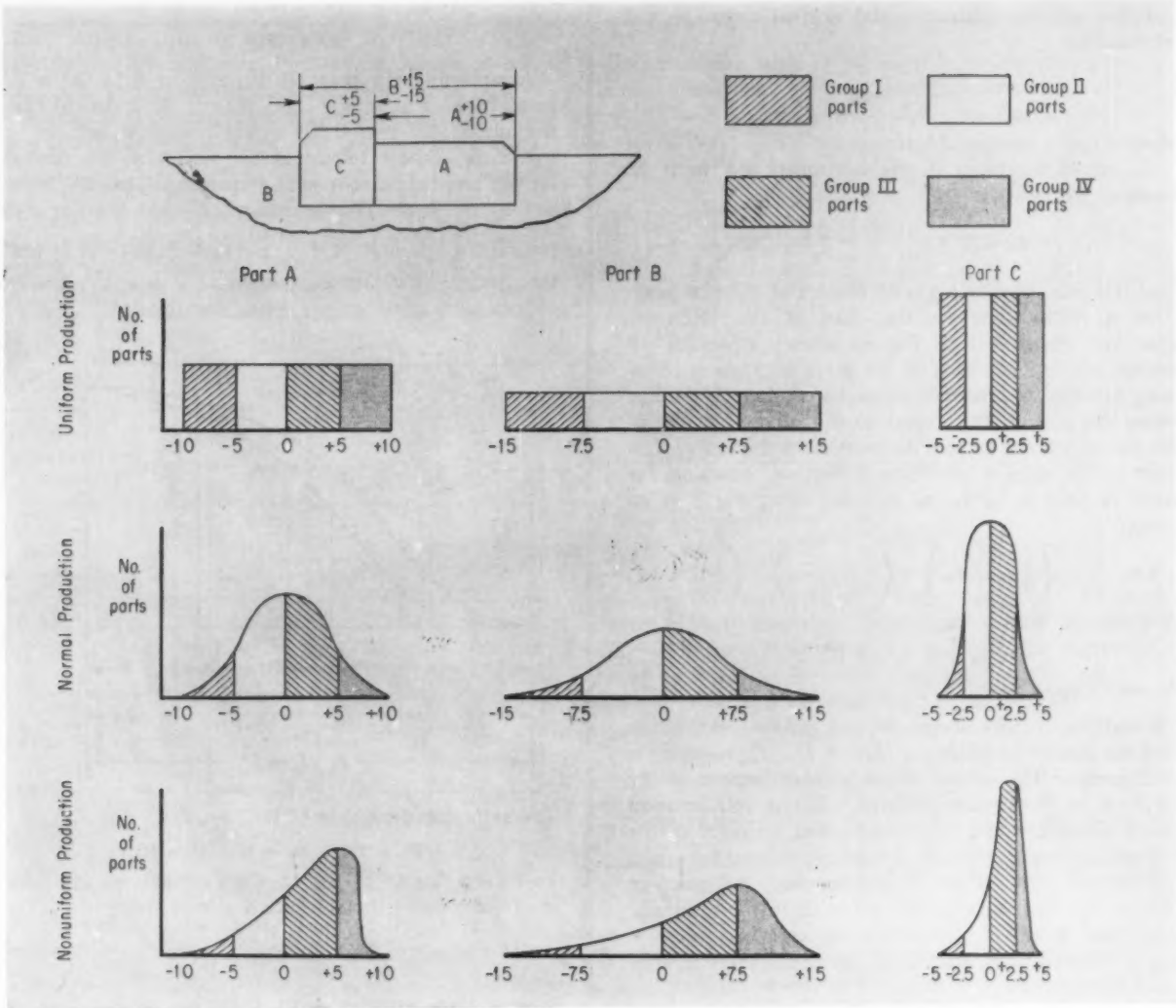
To satisfy condition 2 . . .

This requires that the range of fit be the same for each group. Originally, this range T_L is the arithmetic sum of all part tolerances

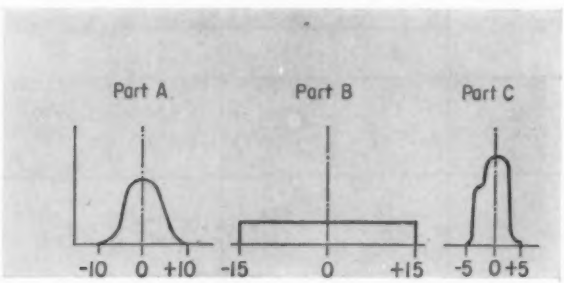
$$T_L = T_A + T_B + T_C \cdots$$

With the improved tolerances of the selective assembly, the range t_L will be

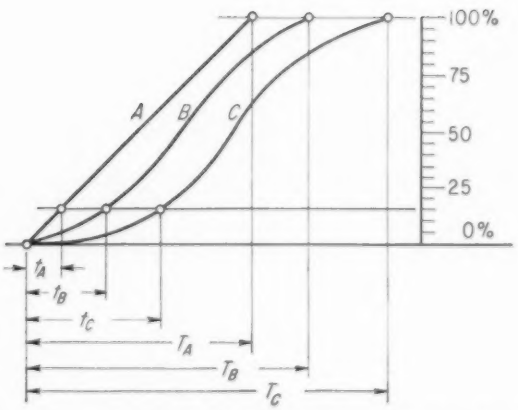
$$t_L = t_A + t_B + t_C \cdots$$



1 . . . DIVIDING PARTS INTO GROUPS, when preparing for selective assembly, is no problem if each part has same distribution pattern, as above. Simply divide total tolerance of each part into equal increments; then match smallest parts to smallest parts and largest parts to largest parts.



2 . . . DIFFERENT DISTRIBUTION PATTERNS for each part makes selective assembly more difficult. If you divide each total tolerance into equal increments, as above, there will be unequal numbers of mating parts in each group and thus, parts left over (condition 1 unsatisfied). If you mark off equal areas under the curve to get the same number of parts in each group, range of fit—the difference between maximum and minimum interference (or clearance)—will be different for each group (condition 2 unsatisfied).



3 . . . SOLUTION TO CONDITION 1 lies in plotting the distribution of dimensions this way. Any horizontal line across the curves marks limits of tolerance range for groups that have equal number of parts.

and this will be related to the original range by the relationship

$$\frac{T_L}{n} = t_L$$

where n is the number of groups.

To satisfy condition 2, the horizontal line must be drawn at the point where

$$t_A + t_B + t_C \cdots = \frac{T_L}{n}$$

Find this point by dividing t_L by number of different parts. Draw a vertical line on the chart at this tolerance. This line (marked I in Fig 4, below) represents an average tolerance for each of the parts of group I. Now using the edge of a piece of paper, find a place on the line where the sum of distances(s) to the curve(s) at left of the line equals the sum of distance(s) to the curve(s) at right. This satisfies condition 2 because, assuming distance to lines is x_A, x_B, x_C etc. and using Fig 4 as an example,

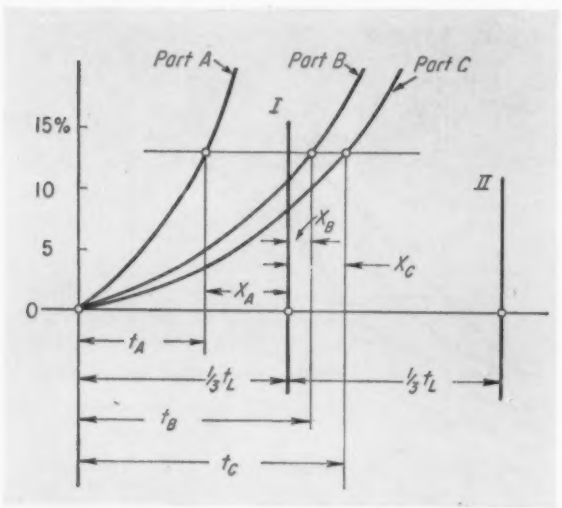
$$t_A + t_B + t_C = \left(\frac{1}{3}\,t_L - x_A\right) + \left(\frac{1}{3}\,t_L + x_B\right) + \left(\frac{1}{3}\,t_L + x_C\right)$$

And since $x_A = x_B + x_C$,

$$t_A + t_B + t_C = t_L$$

To satify condition 3 . . .

Condition 3 can't always be met exactly. It requires that the average interference, $(l_{max} + l_{min})/2$, be equal in each group. This is not always possible because of the variation in distribution patterns. But it will be most closely satisfied if the total as-produced tolerance of the external part equals the sum of total as-produced tolerances for internal parts. Then, simply matching the group of smallest internal parts to the group of smallest external parts, and group of largest internal parts to group of largest external parts, will fulfill this condition with only small discrepancies.

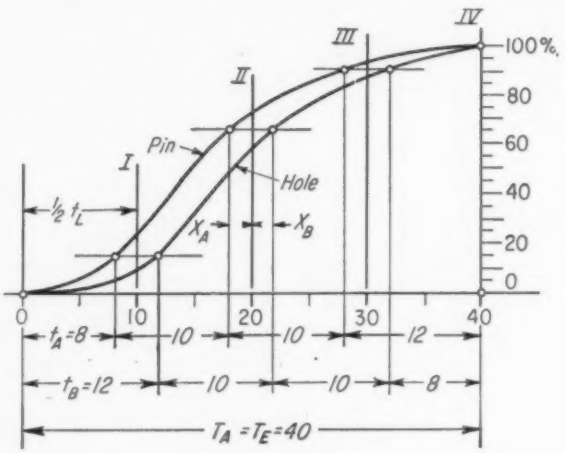


4 . . . SOLUTION TO CONDITION 2 lies in finding the horizontal line that gives equal total tolerance for each group. After drawing line I at 1/3 T_L/n (for three parts with total as-produced tolerance T_L, divided into n groups), find the line that satisfies the relationship $x_A = x_B + x_C$.

EXAMPLE 1

A crankpin with nominal diameter of 4 in. is to be pressed into a hole in a crank throw. It is desired that the interference be -0.003 within a range of ± 0.001.

Initially, choose tolerances that will give the needed average interference but with a range wide enough to be met by the production machines. These tolerances are: pin $= 4\,^{+\,70}_{+\,30}$, hole $= 4\,^{+\,40}_{+\,0}$ (with tolerances in ten-thousands). Plotting dimensions of a sample quantity of both parts gives the two curves shown below.



The as-produced range of fit is

$$T_L = T_A + T_B = 40 + 40 = 80$$

To reduce this to 20 (for $\pm$ 0.001 range) we will have to divide total production into 4 groups giving

$$\frac{T_L}{n} = \frac{80}{4} = 20 = t_L$$

Because there are two parts, draw four vertical lines at $t_{L/2} = 10$ unit intervals. Now finding the points on these lines where $x_A = x_B$, gives the group tolerances. And applying these to the original tolerances gives:

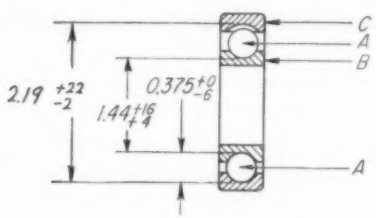
	GROUPS			
	I	II	III	IV
Pin	$4\,^{+38}_{+30}$	$4\,^{+48}_{+38}$	$4\,^{+58}_{+48}$	$4\,^{+70}_{+58}$
Hole	$4\,^{+12}_{+0}$	$4\,^{+22}_{+12}$	$4\,^{+32}_{+22}$	$4\,^{+40}_{+32}$
$t_A + t_B$	20	20	20	20
$\frac{l_{max} + l_{min}}{2}$	$\frac{-18-38}{2} = -28$	$\frac{-16-36}{2} = -26$	$\frac{-16-36}{2} = -26$	$\frac{-18-38}{2} = -28$

Notice that although conditions 1 and 2 are met, condition 3 is not: average interference varies from −26 to −28 whereas as-produced average interference was −30. To correct this difficulty, we will increase the average diameter of the pin, changing tolerances to $4\ ^{+74}_{+34}$. With this correction, average interference is −30 except for groups I and IV where the quantity of parts is small, as shown in this table.

	GROUPS			
	I	II	III	IV
Pin	$4\ ^{+42}_{+34}$	$4\ ^{+52}_{+42}$	$4\ ^{+62}_{+52}$	$4\ ^{+74}_{+62}$
Hole	$4\ ^{+12}_{+0}$	$4\ ^{+22}_{+12}$	$4\ ^{+32}_{+22}$	$4\ ^{+40}_{+32}$
t_A+t_B	20	20	20	20
$\frac{l_{max}+l_{min}}{2}$	$\frac{-42-22}{2}=-32$	$\frac{-40-20}{2}=-30$	$\frac{-40-20}{2}=-30$	$\frac{-42-22}{2}=-32$

EXAMPLE 2

A ball bearing, dimensioned as shown below, is to be selectively assembled to reduce range of clearance. This



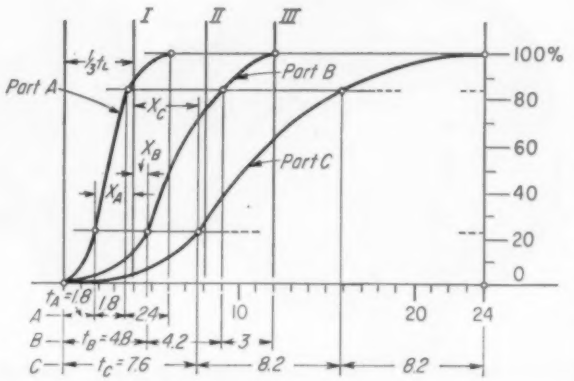
range, if assembled from randomly chosen production parts, would be

$$2T_A + T_B + T_C = (2)\,6 + 12 + 24 = 48$$

and average clearance would be

$$\frac{l_{max}+l_{min}}{2} = \frac{30-18}{2} = +6$$

To reduce the range to 16, we will need to divide production into three groups. Plotting dimensions of a sample lot of parts gives the distribution diagram shown below.



Because there are four parts and production is to be divided into three groups, draw three vertical lines at $\frac{1}{4}\ T_L/3 = 4$ unit intervals. Now find the point on each line where $2x_A = x_B + x_C$. Reading the group tolerances from the graph and applying these to the original tolerances gives the following groups.

	GROUPS		
	I	II	III
Part A (twice)	$0.375\ ^{+0}_{-1.8}$	$0.375\ ^{-1.8}_{-3.6}$	$0.375\ ^{-3.6}_{-6}$
Part B	$1.44\ ^{+16}_{+11.2}$	$1.44\ ^{+11.2}_{+7}$	$1.44\ ^{+7}_{+4}$
Part C	$2.19\ ^{+22}_{+14.4}$	$2.19\ ^{+14.4}_{+6.2}$	$2.19\ ^{+6.2}_{-2}$
$2t_A + t_B + t_C$	16	16	16
$\frac{l_{max}+l_{min}}{2}$	$\frac{14.4-1.6}{2}=6.4$	$\frac{14.6-1.4}{2}=6.6$	$\frac{14.2-1.8}{2}=6.2$

These tolerances satisfy condition 2 and, with average clearances close to 6, nearly satisfy condition 3.

EDITOR'S NOTE: For more design data on how to set production tolerances, see:

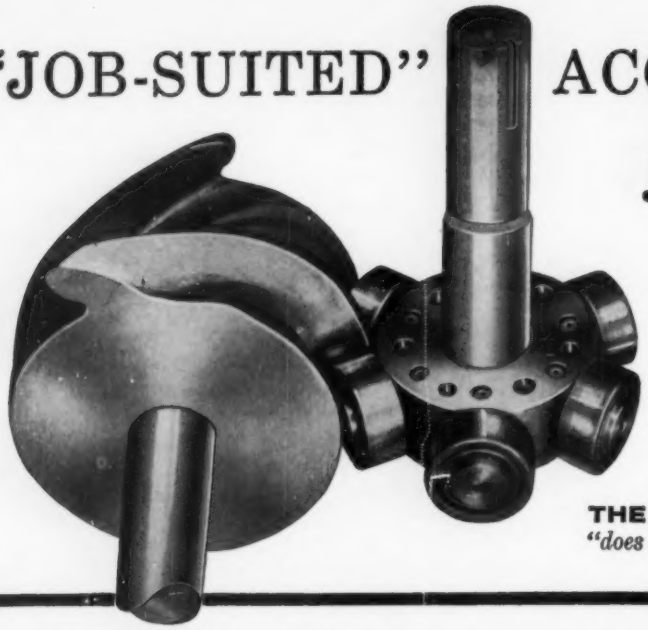
Safe Tolerances for Cumulative Dimensions, Jan 2 '61, p 40—A graphical way to find over-all tolerance on built-up dimensions.

Probability Applied to Assembly Fits, Nov 25 '57, p 88—For short-run production, mathematical probability sets tolerances that are just as reliable as those set by conventional (but more complicated) methods.

Equations Predict Chance of Misfit, May 26 '58, p 61—Check your statistical tolerances with these formulas. They work for assemblies containing any number of parts, telling how many reject assemblies to count on.

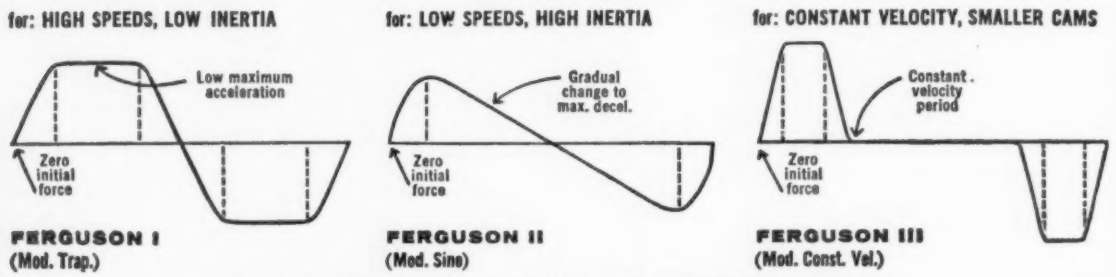
—Charles J Lynch

"JOB-SUITED" ACCELERATIONS... *for high speed indexing and precision cams*



THE FERGUSON DRIVE
"does what no other indexing device can do."

UNIVERSAL SYSTEM OF CAM DESIGN THEORY PRE-SELECTS ACCELERATION ACCORDING TO THE MOTION NEEDED



Three basic acceleration characteristics employed as dictated by the application

Dynamic design becomes increasingly critical as production machinery attains higher speeds. For this reason Ferguson Machine employs the "*Universal System of Cam Design Theory*" which utilizes the type of cam and acceleration configuration calculated to provide the best combination of operating characteristics for the motion desired.

A pre-selected configuration of the plot of **Acceleration vs. Time** is utilized for designing indexing mechanisms, plate, barrel and groove cams and index tables. Cam problems involving unequal times for acceleration and deceleration; compensation for external forces other than inertia; resilient driven members; matching of velocities and low input torque or low impact and centrifugal force requirements are thus taken into consideration and solved.

Movement Time is easily proportioned between **Acceleration Time** and **Deceleration Time** and, when necessary, **Constant Velocity Time.** Established tables based on unity displacement result in design flexibility which facilitates compensation for non-dynamic forces; minimizes vibratory action by considering special characteristics of the inertia load; provides constant velocity periods, etc.

"Job-Suiting" the acceleration characteristic, the only major improvement in the practical application of cams since configuration development itself, is a service much appreciated by Ferguson's customers. You, too, are invited to benefit by the special knowledge Ferguson has accumulated in the field of cam design . . . Send us the facts about any problem related to cam and machine dynamics . . . There's no obligation.

WRITE FOR FREE CATALOG NO. 160—Get full engineering data on the latest in high speed indexing mechanisms, index tables and in-line machine bases. Standard designs employ "Job-Suited" accelerations for your application.

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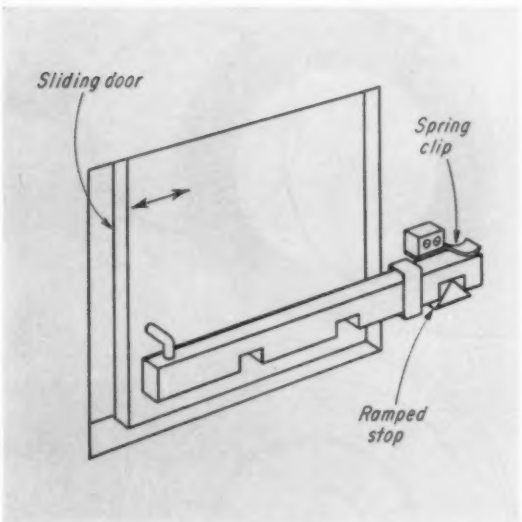
MACHINE COMPANY
A Division of Universal Match Corporation
7818 Maplewood Court • St. Louis 17, Missouri

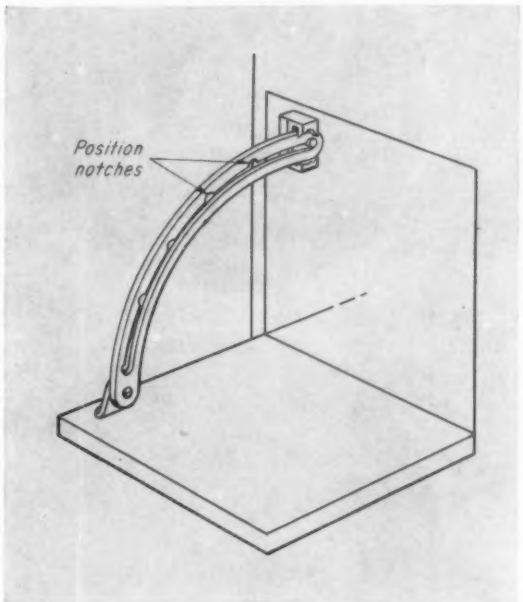
8 STOPS FOR PANEL DOORS

They protect hinges from overtravel and hold doors in working position.

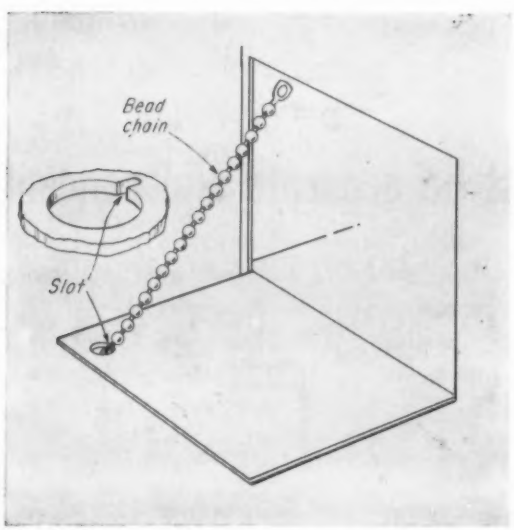
FRANK WILLIAM WOOD JR
President, Advanced Designs Inc
Vienna, Va



1.
SPRING CLIP presses notched bar down on stop for sliding door.



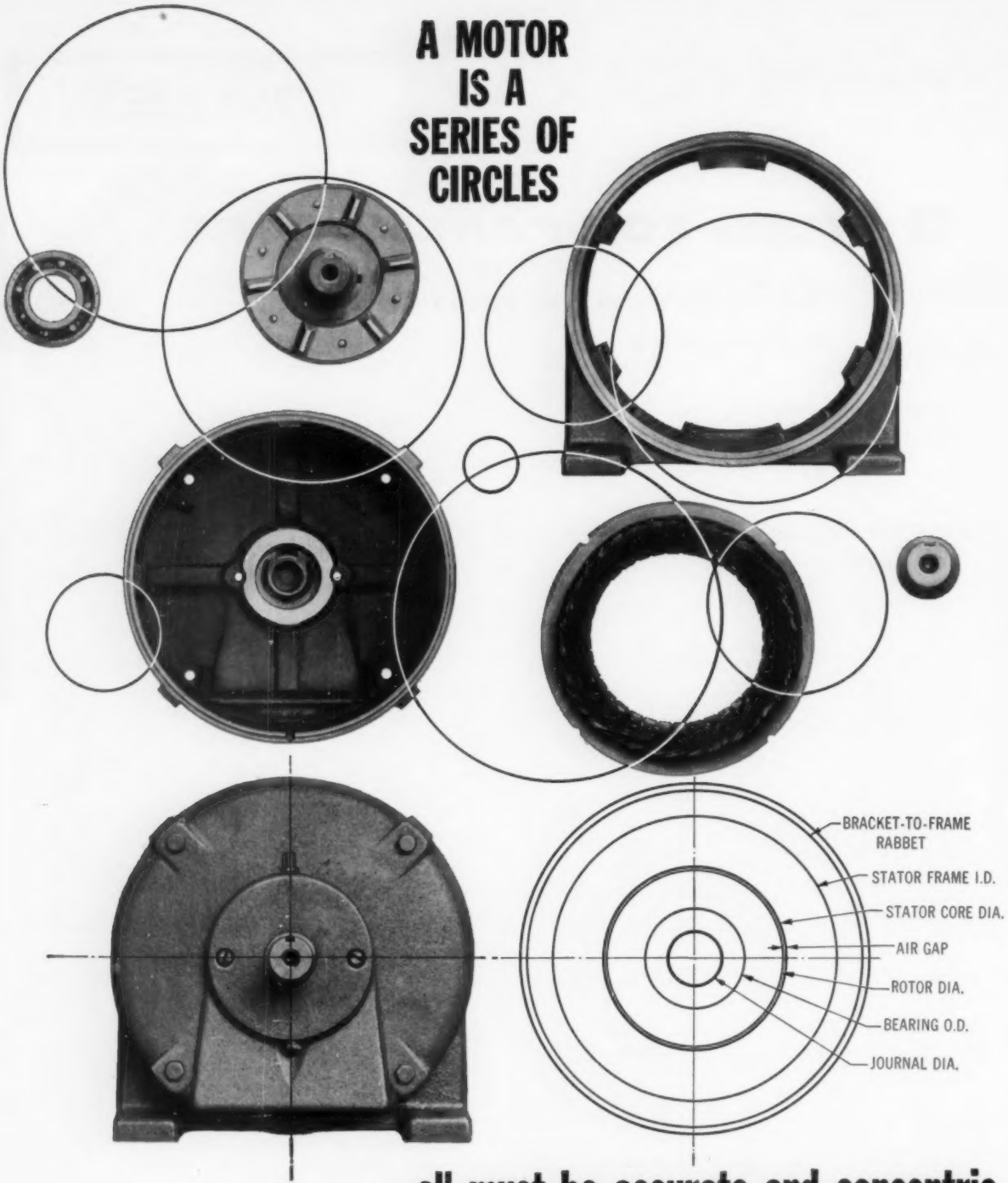
2.
SLOTTED BAR stops when pin jams against end; notches hold drop panel in intermediate positions.



3.
BEADED CHAIN provides as many positions as there are beads. Keyhole slot allows repositioning.

continued on page 65

A MOTOR IS A SERIES OF CIRCLES



all must be accurate and concentric

In manufacturing Elliott Crocker-Wheeler motors, a dozen critical "circles" are formed accurately and concentrically through unique and extraordinarily precise production methods. The result is exact alignment of all parts, true and uniform air gap, free-spinning rotor, quiet, cool, dependable operation.

■ *Elliott Crocker-Wheeler integral-hp a-c and d-c motors—from smallest to largest—are offered in all conventional enclosures and modifications; with insulation to suit the application, including* EPA-SEAL *epoxy insulation for use where conditions are most severe.*

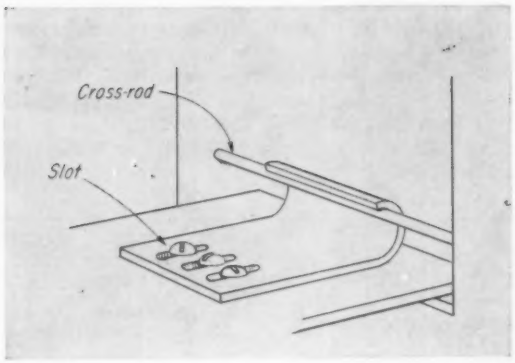
WI-3

ELLIOTT COMPANY

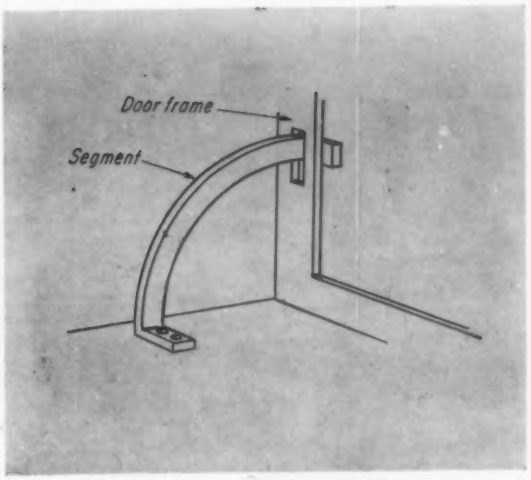
GENERAL OFFICES: JEANNETTE, PENNSYLVANIA

PLANTS AT: Jeannette and Ridgway, Pa.; Springfield, Ohio

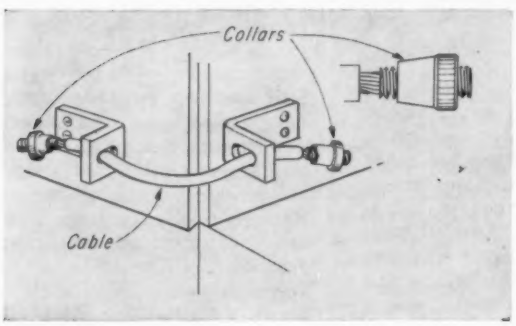
TURBINES · GENERATORS · MOTORS · COMPRESSORS · TURBOCHARGERS · EJECTORS · STRAINERS · TUBE CLEANERS



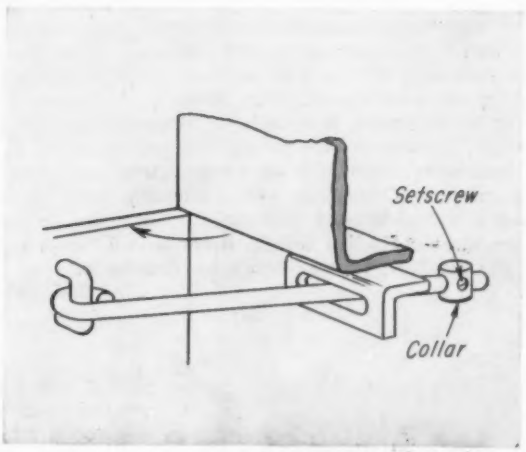
4.
WRAPAROUND back of bar comes to a stop against the cross-rod. Slots permit adjusting bar for different door opening.



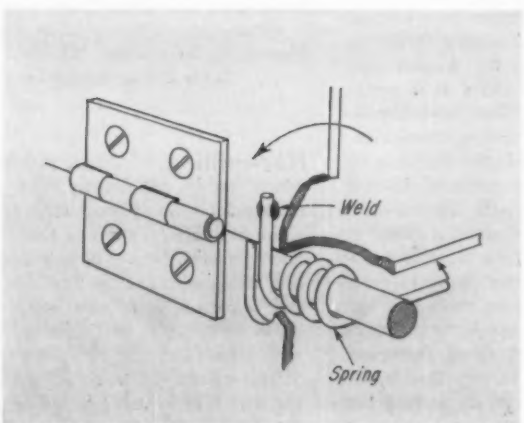
5.
DOG-LEG on end of segment butts against door frame.



6.
CABLE pulls taut on end collars, which screw back and forth for slight adjustment.

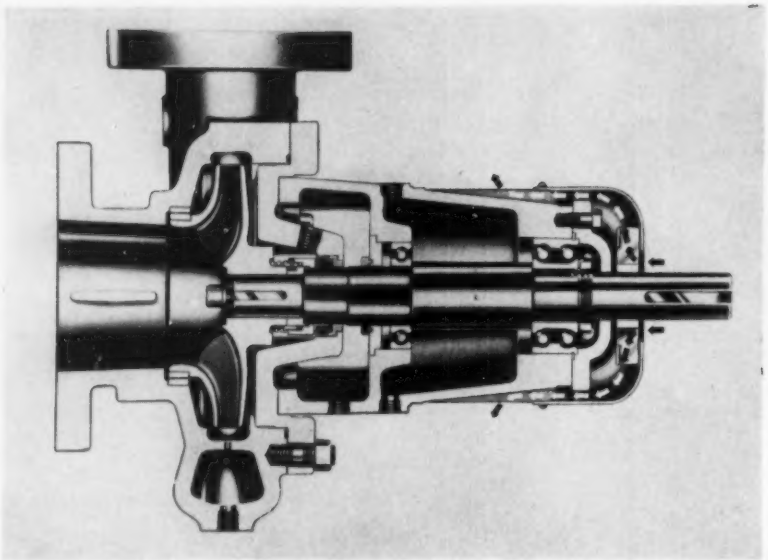


7.
COLLAR slides along rod to adjust stopping point.



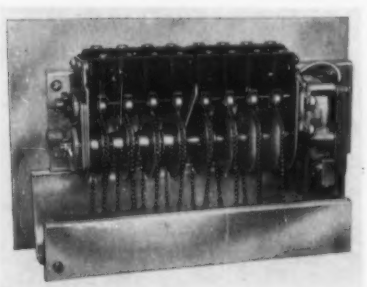
8.
COIL SPRING swings into underside of shelf and cushions door to a soft stop.

SIGNIFICANT COMPONENTS MATERIALS, PROCESSES



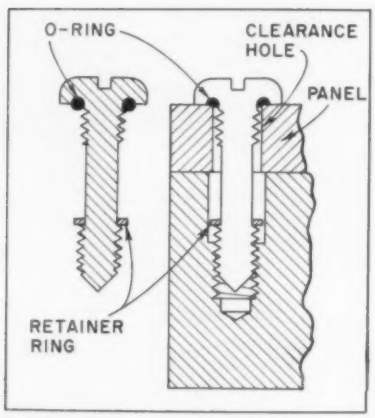
Interchangeable pump parts . . .
on two basic units—one for high-temperature and another for lower-temperature service—make up to 72 combinations possible. Requirements for any type service can be met by interchanging impellers, covers, nozzle arrangements, bearing construction, cooling methods and other components from stock. Entire line has built-in fan cooling system, eliminating need for a cooling water supply to bearings in many applications. High-temperature model, with either single- or double-stage construction, as well as single or double suction, is available with capacities to 1200 gpm, differential heads to 1600 ft, pressures to 1000 psi and temperatures to 850 F. Vertically split with centerline-support mounting, it has a water-jacketed stuffingbox for either packing or a mechanical seal. Other basic unit is internally sealed version of former, using a mechanical seal as standard construction. Capacities are same, with exception of max temperature, which is 400 F. **Byron Jackson Pumps Inc, Sub of Borg-Warner Corp, PO Box 2017, Terminal Annex, Los Angeles 54.**

Circle 300 on Reader Service Card



Bead-chain timer . . .
has a drive sprocket rotating an endless stainless-steel bead chain, instead of a cam as found on conventional synchronous motor-driven timers. Large beads are applied at points along chain to actuate a stepping switch at desired time (switch is mounted in such a way that a roller type actuator rides on the chain as it passes around the sprocket). These beads can be applied singly to close the switch momentarily, or grouped to hold the switch in an actuated position. Since length of circuit is unlimited, it is possible with different drive speeds to have an unlimited number of timed programs. Also, it is possible to obtain very short actuations (down to every 20 sec) by rotating a long chain at a fast rate of speed using single large beads (length of chain and speed determine length of actuation), or very slow cycles (up to one cycle per yr) by making the chain longer. Input voltage and frequency depend upon synchronous motor used. Price, varying with model and number of circuits, averages $250. Delivery in an average of 90 days. **Eagle Signal Co, 202 20th St, Moline, Ill.**

Circle 301 on Reader Service Card



Self-sealing captive screw . . .
using a grip ring on blind side of a panel as a retaining device, eliminates need for thread-tapping panels and covers. Ring also prevents accidental unscrewing, cross-threading or thread-locking. Each thread size from 2-56 to ¼-20 accommodates standard clearance holes in panels or covers $\frac{3}{32}$ to ¼-in. thick, with only one length required. Seals internal and external pressures of more than 500 psi and can be tightened and loosened many times without losing sealing power. Standard pan-head screw comes in stainless steel with silicone rubber O-ring. Other head types and materials furnished on request. Small quantities from stock; delivery in 1 wk on other orders. **APM Corp, 41 Honeck St, Englewood, NJ.**

Circle 302 on Reader Service Card

Non-milling silicone rubber
which can be fed directly from package to extruder without pre-milling, is said to retain fresh life for a min of three months. Recommended for use as extruded insulation on power cable, fixture wire, motor and apparatus lead wire, etc, material shows following properties as extruded on wire: tensile strength, 800 psi; elongation, 550%; volume resistivity, 2.5 x 10^{16} ohm-cm; and electric strength, 700 v per mil. Available in two forms: one for hot air

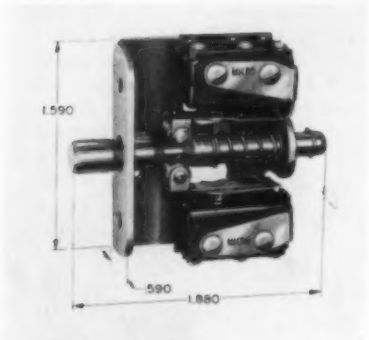
vulcanization and another suitable for CV steam curing techniques. From stock in 2-in. wide, ½ or ¼-in.-thick coiled strips. **Silicone Products Dept, General Electric Co, Waterford, NY.**

Circle 303 on Reader Service Card

Low-pressure alarm . . .

is self-contained, self-energized unit which sounds alarms when cylinder pressure drops to 450 lb per sq in. Uses compressed gas itself as motive power, requiring no electrical power, switches or gages. Audible warning automatically sounds at predetermined point and continues to ring for 3 to 6 min. (depending on cylinder size) or until system pressure increases to point above preset warning pressure. Consumes only minute quantity of gas during ringing period. From stock at $19.75. **Scott Aviation Corp, 372 Central Ave, Lancaster, NY.**

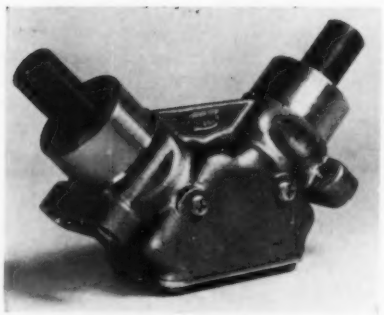
Circle 304 on Reader Service Card



Interlock switches . . .

automatically cut current when door of cabinet or enclosure containing electrical equipment is opened, and reenergize circuit when door is closed. For electrical checkouts, interlocks can be set to maintained-contact position, eliminating need for cheaters or jumpers. Available in three series. One (13AC1 series) for data processing consoles, transmitters and computers, eliminates even momentary power interruptions when cabinet door is closed and is UL-listed for 10 amp at 125 or 250 v ac; ½ amp at 125 v dc; and ¼ amp at 250 v dc. The 8AC1 series controls up to four separate SPDT circuits at one time, with each of four switches rated at 5 amp at 125 or 250 v ac, 30 v dc. Inductive ratings are 30 amp at sea level and 2.5 amp at 50,000 ft; resistive ratings, 5 amp at sea level and 50,000 ft; and max inrush rating, 24 amp. Sealed interlocks comprise 9AC series. Subminiature switches are sealed in epoxy resin inside housing with elastomer plunger seal bonded to pin plunger and metal housing. Have same electrical characteristics as 8AC1 series. From stock at $5.24 for 13AC1 series; $16 for 8AC1 series; and $12.80 to $15.05 for 9AC models. **Micro Switch Div, Minneapolis-Honeywell Regulator Co, Freeport, Ill.**

Circle 305 on Reader Service Card



90° gearbox . . .

suitable for making sharp bends in rotary-type remote-control linkages, consists of cast bronze housing and two spindles with bevel gears supported in needle bearings. Gears are splined internally and pinned for lateral holding only. Spindle stub shafts come either keyed or splined in any required diameter to attach to universal joints for reach rod controls or to attach to flexible shafting. Relatively short spindles allow gearbox to be fit into sharp corners. Available in three sizes with torque capacities of 500, 2000 and 3500 in.-lb and said to be approx 88% efficient. Prices are $49.20, $56.90 and $69.50. Delivery in 1 mo. **Stow Mfg Co, 426 Shear St, Binghamton, NY.**

Circle 306 on Reader Service Card

Ethylene copolymer . . .

contains no plasticizer and is said to be easily injection-molded, blow-molded and extruded in conventional equipment. Reportedly equal to rubber in flex-cracking resistance, vinyl in stress-cracking resistance, and low-density polyethylene in resiliency and elongation properties, material is suitable for industrial bellows, diaphragm pumps, moldings, gasketings, etc. At room temperature, its torsional stiffness is same as 90A durometer elastomeric vinyl; at —13 F, it is said to be nine times as flexible. In flex-cracking tests at 32 F, material survives more than 2 million cycles. Low density of 0.93 is said to make copolymer competitive (current price: 32½¢ per lb) with higher specific gravity, low pound-cost materials. **Union Carbide Plastics Co, Div of Union Carbide Corp, 270 Park Ave, New York 17.**

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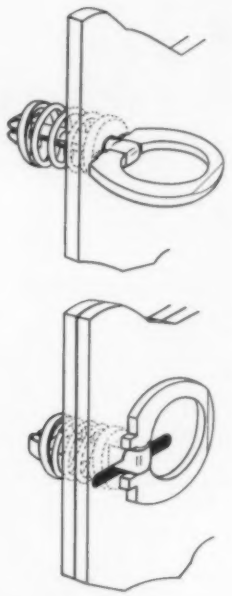


Spring-loaded latch . . .

for removable panels and access doors, reportedly can be installed in one quarter the time of other closures. Requires no riveting, screws, spotwelding or special tools. Noise transmission and vibration are eliminated by cadmium-plated latch's spring tension. Accommodates thicknesses up to ¼ in. **Monadnock Mills, San Leandro, Calif.**

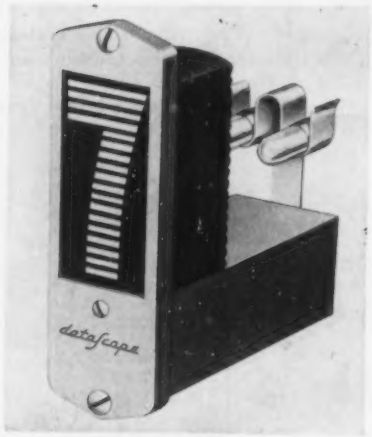
Circle 308 on Reader Service Card

Inertial switch . . .

measuring 1 in. high x 1 in. in dia, is a self-locking unit set to specified "g" levels over range of 5 to 25 g's. Response time can be set between 25 and 200 millisec. Triggers specific functions in relation to an imposed "g" level (can be used for direct circuit closure or opening, or to actuate relays, thyratrons and similar devices). Self-locking device holds switch in actuated position after proper "g" level has been imposed. Switch then can be reset with small tool without being removed from vehicle. Weighs between 2 and 3 oz, depending upon specifications, and is said to last for a min of 25,000 cycles. **Instrument & Controls Dept, Sanders Associates Inc, 95 Canal St, Nashua, NH.**

Circle 309 on Reader Service Card

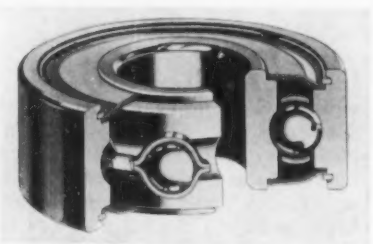
continued on page 68



Self-decoding readout . . .

which mounts in a 1 x 3.1-in. panel space and extends only 2.5 in. behind panel, decodes either binary inputs or pulse trains and displays information in digital form. Sixteen ¾ x 1¼-in. alpha-numerical characters are displayed at rate up to 50 per sec. Of 16 symbols, 10 are normal decimal digits and other six are available to specification. Built-in memory feature keeps last character in position with no power requirement. Two incandescent bulbs, wired in parallel, light instrument. If one bulb burns out, other continues to illuminate the display. Operates on either 12 or 28 v dc; requires 0.57 w-sec per bit power; and can be used singly for one-digit readout or gang mounted to meet any display sequence. Priced from $20 to $50 depending upon quantity. Delivery in 4 wk. **Datascope Corp, 4023 Irving Pl, Culver City, Calif.**

Circle 310 on Reader Service Card



Sealed bearing . . .

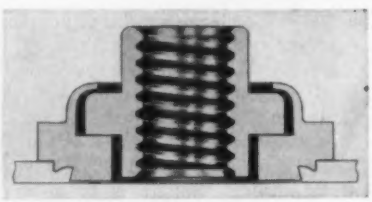
has fiber-aluminum laminate sealed against ground surface of inner ring to block out dirt and retain bearing lubricant while operating at high speeds (as high as unsealed bearing) in moderate to high temperatures. Friction of rubbing seal is said to be negligible. In operation, units have been used up to 3000 hr at 80,000 rpm without damage or loss of efficiency. They also have tolerated lineal speeds of 6000 fpm, compared with usual 2000 to 3000 fpm toleration limits for most sealed bearings. Continuous operating temperatures range up to 300 F. Available in 10 unflanged and three flanged sizes from 0.3125 to 2.4409 in. OD. Priced slightly higher than ABEC-7 shielded bearing. **Barden Corp, 200 Park Ave, Danbury, Conn.**

Circle 311 on Reader Service Card

Tungsten tool and die steel

is a deep-hardening grade, said to offer up to four times the life of high-carbon, high-chrome steels. Reportedly can be heat-treated at much lower temperatures than those required for others steels used in max wear-resistant applications. Hardens through to center in sizes up to 6-in. cross section when oil quenched from 1450 F. Intricate shapes up to 2 in. in dia can be air hardened from 1550 F. Grade is essentially a nondeforming tool and die steel with min size change occurring after tempering at 300/400 F. It is not recommended for applications where service temperatures exceed 350 F. Cannot be annealed sifter than about 255/265 Brinell, but despite high hardness, is said to machine at least as well as high-carbon, high-chrome types. **Carpenter Steel Co, 101 W Bern St, Reading, Penna.**

Circle 312 on Reader Service Card



Self-locking nut . . .

clinched by a squeeze into prepared holes in sheetmetal, compensates for errors of up to 1/32-in. in mating-hole alignment. Available in sizes No. 4 to ¼ in. and is suitable for sheet thicknesses from 0.040 in. up and materials with Rockwell hardness of B-70 or less. One type has cadmium- or cadmium chromate-finished steel retainer with nut of 18-8 stainless steel, passivated and with dry film lubricant. Another type is stainless steel throughout, also passivated and with dry film lubricant. **Penn Engineering & Mfg Corp, Doylestown, Penna.**

Circle 313 on Reader Service Card

Cam-action coupling . . .

is suitable for closures normally requiring as many as 24 nuts and bolts. Anywhere from two to five cams are used on each flange, with each cam replacing from four to six bolts. Once the two flanges have been brought together, they are locked in place by partial, 3-sec turn of each cam. Only tool required is a ⅜-in. dia rod. Leakproof seal is provided by permanently positioned O-ring gaskets. Coupling, available for openings of from 2 to 16 in. in dia, is rated at 150 lb. ASA (number of cams can be reduced when pressures lower than 150 lb are used) and is hydrostatically tested at 450 psi. Temperature range is —70 to 400 F. Cams are made of AISI 410 stainless steel; flange faces are nickel plated. **Camlock Flange Sales Corp, 39 Redfern Ave, Inwood 96, LI, NY.**

Circle 314 on Reader Service Card

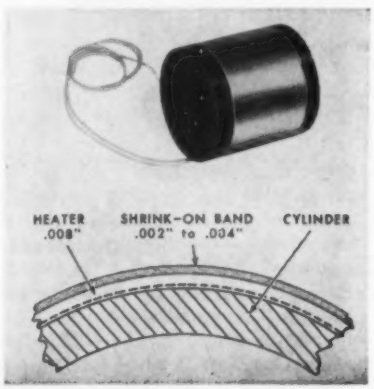
Hydraulic swivel . . .

has metallic seals built for balanced hydraulic loading on metallic seats. These seals lock in highly pressurized hydraulic fluids passing through active swivel. The stainless steel unit handles hydraulic fluids such as Oronite and Skydrol under pressures up to 6000 psi. Functional temperature ranges from a liquid nitrogen low to high of 650 F. Low-lubricity synthetic hydraulic fluids are said to be sealed effectively over entire operating temperature range. Available in right-angle and straight-through configurations. **Press-Temp Products, Div of Propulsion Development Laboratories Inc, 1120 E El Segundo Blvd, El Segundo, Calif.**

Circle 315 on Reader Service Card

Flat-element flexible heater

is less than 0.008 in. thick, yet has insulation resistance of well over 1000 megohms. Can be installed on cylindrical surfaces without adhesives by means of a shrink-on band which is slipped over both heater and cylinder. A few minutes in a 200 to 225 F oven shrinks installation band to hold heater in close contact with surface to be heated. Over-all thickness of heater and band is 0.010 to 0.012 in., except over leads where thickness depends on



those specified. Max and rapid heat transfer is said to result from thin layer of insulation (0.001 to 0.002 in.) separating flat foil heating element from heat sink

continued on page 71

Mr. Design Engineer:
Is high torque strength of interest to you?

Take a look at the reinforced Plaskon® Nylon specified by a prominent manufacturer for their newest outboard propeller. The material is Nylafil G-3 — Plaskon Nylon reinforced with glass fibers under carefully controlled conditions by the Fiberfil Corporation, Warsaw, Indiana.

They chose this material because of its outstanding tensile and flexural strength which enables it to meet the high torque requirements of an outboard propeller. Also important are its excellent resistance to corrosion and electrolysis, outstanding impact resistance, light weight, improved dimensional stability, and fine resistance to abrasion (propellers are tested by running over sand bars and oyster beds).

Even if your field isn't marine engineering, these properties should be of interest to your particular design problem. Let our Applications Engineering Group work with you — write our Nylon Design Department.

PLASTICS DIVISION
40 Rector Street, New York 6, N. Y.

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CIRCLE 69 ON READER SERVICE CARD

New f/2.3 ZOOM LENS

For 16mm FASTAX High Speed Motion Picture Cameras

WF-220

- Complete versatility with only one lens . . . 28mm to 75mm
- Critically sharp throughout focal range . . . 1" to 3"

The Wollensak Varifocus Zoom Lens increases the effectiveness of the FASTAX by permitting various degrees of wide angle and telephoto coverage with one lens . . . always with you, ready for action. Crisp, clear images anywhere in the focal range. Aperture of f/2.3 throughout the entire focusing range of 5 feet to infinity. Calibrated focal lengths, distance and aperture markings.

ALSO 20-60mm f/1.8 Varifocus Zoom for C mount cameras.

400' 16mm *FASTAX* CAMERA

Combined Motion Picture and High Speed Oscillographic Recorder *with* *STOP-START Capability*

WF-14ST

SPECIAL

2-sided Prism Delivers . . .

- Even Density over Full Frame
- High Corner-to-Corner Resolution
- Faster Stopping Action

With stop-start feature FASTAX cameras can be rapidly stopped at any point permitting multiple runs througout 400 foot roll. Operable at any frame rate.

The WF 14ST Camera stops action faster with clearer pictures at a given frame rate . . . up to 6,000 pps.

Write for literature on FASTAX Cameras, Zoom Lens

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OPTICAL COMPANY, ROCHESTER 21, N. Y.

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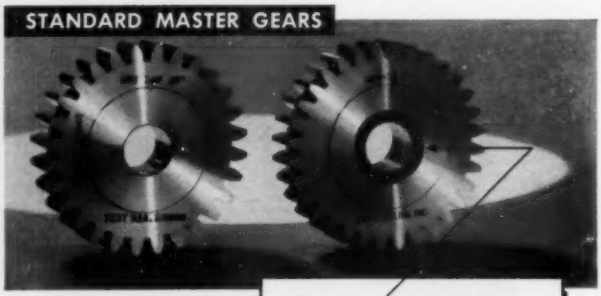
FINE AND COARSE PITCH

STANDARD MASTER GEARS



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FINE PITCH MASTER GEARS are now available with a TUNGSTEN CARBIDE BUSHING which increases gear life many times by maintaining the original bore accuracy.

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What's Your Toughest Surface Measurement Problem—

- ☐ Measuring roughness of parts that are
  - ☐ Extra-smooth? ☐ Inside small ID's?
  - ☐ Short or narrow? ☐ Remotely located?
  - ☐ Concave or convex? ☐ Of critical importance?
- ☐ Measuring height and width of waves, bows, steps and other widely-spaced irregularities?
- ☐ Measuring individual pits, flaws, scratches?
- ☐ Measuring waviness around surfaces of rotation?
- ☐ Other:_____

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CIRCLE 70 ON READER SERVICE CARD

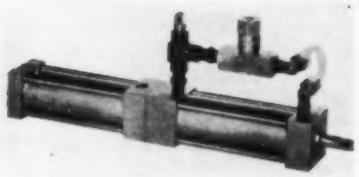
surface. Noninductive element is available with resistance up to 500 ohm per sq in. and power dissipation of up to 15-w per sq in. when installed on a heat sink and controlled to 200 F or less. Also can be made in unusual shapes for heat concentration in particular areas. Delivery in 3 wk on prototype quantities. **Minco Products Inc, 740 Washington Ave N, Minneapolis 1.**

Circle 316 on Reader Service Card

General-purpose air cylinder

rated 200 psi max, is available in 1½-, 1¾-, 2½-, 3⅜- and 4½-in. bore sizes with standard strokes to 20 in. and in single and double rod end models. One-piece, nonscore piston construction eliminates metal-to-metal contact on cylinder body and stroke ends and pressure-adjusted sealing element serves as rod wiper. Floating cushions to reduce stroke impact can be furnished when ordered or added in field without increasing over-all length. Three basic mounting positions—side, cap end or head end—are provided, while four mounting attachments can be supplied on request. **Hannifin Co, Dept 126, 501 S Wolf Rd, Des Plaines, Ill.**

Circle 317 on Reader Service Card



Air-oil tandem cylinders . . .

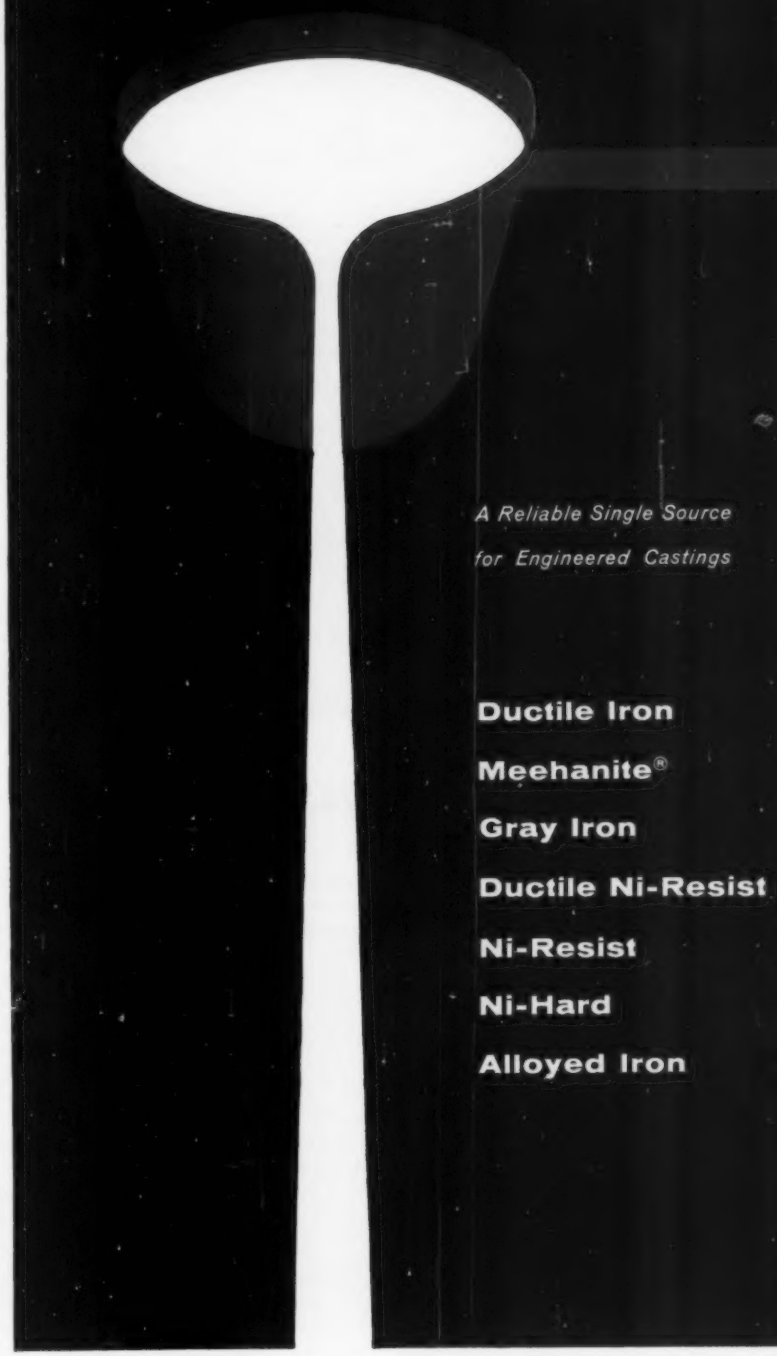
combine air operation with accurate speed control available in hydraulic cylinders. Available in ¾-, 1- and 1½-in. bore sizes and eight mounting styles. Max pressure is stated at 200 psi. Include non-corrosive barrels; strainless steel piston rods with lip-type rod seals; Delrin rod bushings; Teflon rod wipers; and choice of O-rings or lip-type piston seals. **Pneumatic-Hydraulic Development Co, Tom Thumb Div, 317 W Masterson, Fort Wayne, Ind.**

Circle 318 on Reader Service Card

Cadmium sulphide photocell . . .

said to be approx 10,000 times more sensitive than conventional phototube, actuates large relays without intermediate amplifier stage. Side-sensitive device features a dark current of 2.5 microamps; an average cell current of 10 ma with 5.0 ft candles illumination (color 2700° K); and

continued on page 72



HAMILTON FOUNDRY INC.

1551 LINCOLN AVENUE • HAMILTON, OHIO • TWinbrook 8-7491

CIRCLE 71 ON READER SERVICE CARD

dissipation rating of 1 w. Mounted in a hermetically sealed glass envelope with conventional 7-pin miniature base, enabling it to replace phototubes now in use. **Amperex Electronic Corp, Semiconductor & Special Purpose Tube Div, 230 Duffy Ave, Hicksville, LI, NY.**

Circle 319 on Reader Service Card

Hi-temp locknut . . .

made of a nickel-base alloy, is for use with high-strength 1200- and 1400-F bolts. Self-locking, prevailing-torque type nut is rated at a room temperature tensile strength of 180,000 psi min. Min tensile rating at 1200 F is 130,000 psi and at 1400 F is 100,000 psi. Initial stress at 1200 F is 90,000 psi and at 1400 F, 75,000 psi. Residual stress after 150 hr is 70,000 psi at 1200 F and 37,000 psi at 1400 F. Available in size #10-32 through ¼-20 and formed for use on 0.003-in. reduced dia bolt threads. **Standard Pressed Steel Co, Jenkintown, Penna.**

Circle 320 on Reader Service Card

Slip-ring assembly . . .

for use on instrumentation circuits, accommodates from 15 to 30 rings and is said to have a low noise level. Current capacity is 2 amp, 250 v ac, 60 c and speed, up to 1200 rpm. Measures 4½ in. in dia and 8¾ in. high and weighs less than 3 lb. Max shaft dia is 1¼ in. **Superior Carbon Products Inc, 9115 George Ave, Cleveland 5.**

Circle 321 on Reader Service Card

Air filter for 2-in. lines . . .

passes 600 cu ft of air per min., with only 1-lb pressure loss. Working pressure is 125 lb; unit weight, 26 lb. Need for cleaning is indicated by air gages on inlet and outlet, which show line pressure and pressure drop. Cleaning and replacing element requires removing only one flange ring and one nut. Transparent plastic bowl allows sediment or excess water to be seen (metal bowl is recommended for installations where heat is over 120 F). In even sediment clogs automatic dumping device, a manual trip allows it to be cleaned by full line pressure. Then trap returns to full automatic operation. Moisture removal is complete, due to centrifugal action, protective shroud over element and quiet zone baffling. Prices range from $142 for unit with metal bowl and no trap and gages to $158 for unit with plastic bowl and guard, gages and trap. **Techmatic Specialties Inc, Royal Oak, Mich.**

Circle 322 on Reader Service Card

Double-acting cylinders . . .

with choice of stroke length are designed for 10,000 psi. Available in bore sizes of 1½, 2 and 2½ in. with "push" capacities of 8, 15 and 25 tons at 10,000 psi. Although designed as "push" cylinders, have sufficient "pull" (piston return) force to return ram from such work as punching, forming, broaching, etc. where spring return is inadequate. Continuous "pull" duty is limited to 3000 psi, but units can withstand 10,000 psi in occasional "pull" use. **Owatonna Tool Co, 727 Cedar St, Owatonna, Minn.**

Circle 323 on Reader Service Card

Temperature probes . . .

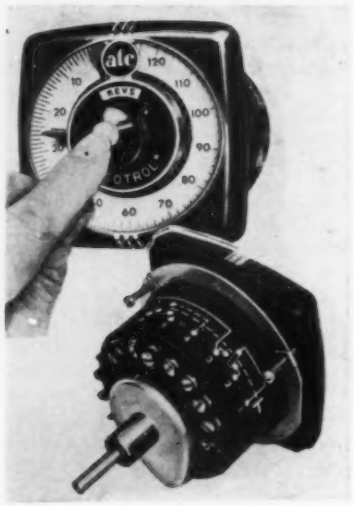
for —450 to 1500-F service, have sensing elements of either high-purity tungsten, platinum, balco, or nickel, in which resistance is a sensitive, linear function of temperature. Types include those with elements fully enclosed in stainless steel tubes for immersion in conductive or nonconductive gases or liquids at high stream velocities. Others have partially-enclosed elements for following rapid changes in temperature. Resistance ranges are 20, 200, 500 and 20,000 ohms; calibration points, 32 and 212 F. **Astra Technical Instrument Corp, 12930 Panama St, Los Angeles 66.**

Circle 324 on Reader Service Card

Digital voltmeter . . .

has plug-in stepping switches, which can be replaced in less than a minute. The four-digit instrument with ±0.01% accuracy measures dc voltages from within 0.001 to within 999.9. Addition of a preamplifier extends its range to within 99.99/999.9 milliv full scale. With ac/dc converter, it measures ac voltages from 0.001 to 999.9 in ranges of 9.999/-99.99/999.9 v, 30 c to 10 kc. Has input impedance of 10 megohms, or 1000 megohms on lowest range, and automatic selection and indication of range and polarity. From stock at $1525. **Non-Linear Systems Inc, Del Mar, Calif.**

Circle 325 on Reader Service Card



Revolution counter . . .

can be directly coupled to a rotating shaft and driven at any speed (constant or variable) up to 2000 rpm with repeat count accuracy of ¼ to 1% of dial range. Available in 11 dial ranges—from 0-12 to 0-6000 revolutions. Suitable for batch type or single function cutoff applications when cycle is to be manually initiated, unit has controller with mechanical latch mechanism in place of an electric clutch. Shaft requires operating drive torque of 1¼ in.-oz max. **Automatic Timing & Controls Inc, King of Prussia, Penna.**

Circle 326 on Reader Service Card

Electronic tachometer . . .

measures shaft speeds from 0 to 2500 rpm. Has an electronic metering panel and remote pickup head, requiring no current flow in actual operation. Circuit is actuated by front panel switch and is said to have fast response for quick shaft speed readout. Pickup head can be attached to any shaft end by a single stud bolt. Two models are available: one for speeds of 0 to 60 rpm and another for speeds up to 2500 rpm. Standard plastic panel measures 4¾ x 6½ and has 3-in. meter. **Rampe Mfg Co, 14915 Woodworth Ave, Cleveland 10.**

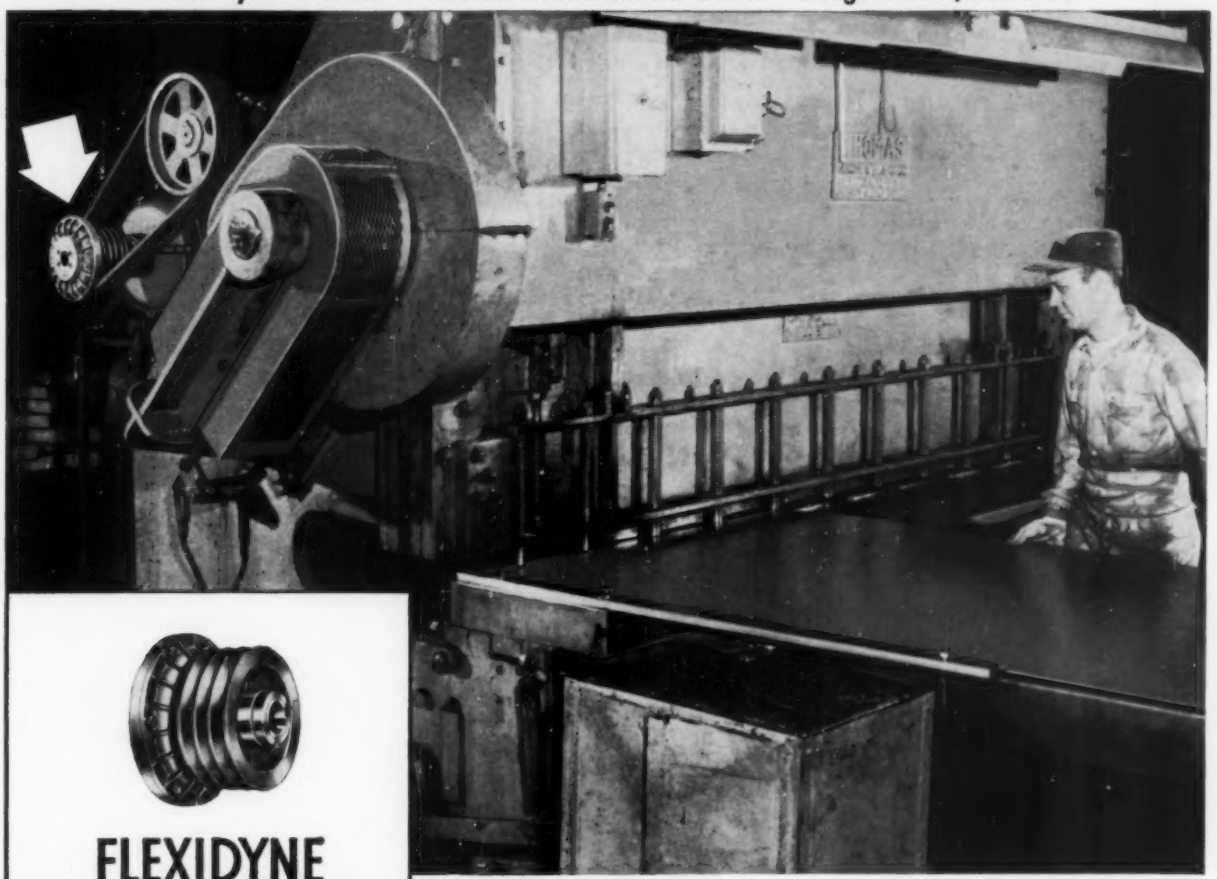
Circle 327 on Reader Service Card

10-amp relay . . .

measuring 1 x 0.6 x 1.25 in. and weighing 2.5 oz, withstands shock and sustained acceleration of 50 g's and vibration of 30 g's up to 2000 cps. Hermetically-sealed unit has all-welded construction; is highly

continued on page 74

See Flexidyne in action at DESIGN ENGINEERING SHOW—Dodge Exhibit, Booth 322

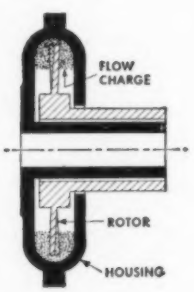


FLEXIDYNE

THE DRY FLUID DRIVE

The "fluid" in Flexidyne is heat treated steel shot. A measured amount, called the flow charge, is contained in the housing which is keyed to the motor shaft. When the motor is started centrifugal force throws the flow charge to the perimeter of the housing, packing it between the housing and the rotor which transmits power to the load.

After the starting period of slippage between housing and rotor the two become locked together and achieve full load speed, operating without slip and at *100% efficiency*.



Look, Folks...No Strain!

— saves motors and V-belts!

— cuts starting current draw!

Introduce Flexidyne into your drive system and your stubborn loads take off smoothly, without the necessity of oversize motors or costly controls. Flexidyne provides the equivalent of a "no load" start, reduces maintenance, protects motors against shock or overload, and operates at 100% efficiency at full load speed!

Across the nation — on shears, mixers, agitators, blowers, chippers, ball mills, cranes, conveyors, cotton cards, jaw crushers, *everywhere* — thousands of Flexidynes are performing brilliantly. Here is the *new and better way* to start loads smoothly!

Flexidyne is available from stock in 8 drive sizes and 10 coupling sizes for capacities to 1000 hp. Ask your Dodge Distributor, or write us for complete technical bulletin.

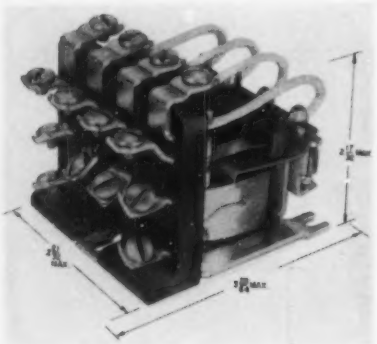
Dodge Manufacturing Corporation, 1200 Union St., Mishawaka, Indiana

The Products with the Pluses... **DODGE** *of Mishawaka, Ind.*

CALL THE TRANSMISSIONEER, your local Dodge Distributor. Look under "Dodge Transmissioneer" in the *white* pages of your phone book. Factory trained by Dodge, he can give you valuable assistance.

resistant to moisture and temperature extremes; and has tested life of more than 150,000 operations at 10 amp, 26.5 v dc, or 115 v ac at 257 F. Priced at approx $8 each. **Wheelock Signals Inc, 273 Branchport Ave, Long Branch, NJ.**

Circle 328 on Reader Service Card



4PDT power relay . . .

occupies approx same space as 2-pole relay, measuring $3\frac{13}{32}$ x $2\frac{21}{64}$ x $2\frac{1}{2}$ in. Has mechanical life of over 10 million operations at a max of 2 cycles per sec with 50% dwell time. Rated load life is over 100,000 operation at max of 14 cycles per min with 50% dwell time. Sample quantities of 115 v, 50/60 c units are available at $12.35 each. **Potter & Brumfield Div, American Machine & Foundry Co, Princeton, Ind.**

Circle 329 on Reader Service Card

Size 5 motor-generator . . .

weighs 1.1 oz and measures 1.565 in. long. Motor and generator, contained in single stainless steel housing, rotate on common shaft. Excitation voltage is 26 v, 400 c. Motor's torque at stall is 0.1 oz-in.; acceleration at stall, 37,000 rad/sec^2; and no load speed, 10,000 rpm. Generator output is 0.20 v per 1000 rpm; phase shift, 13° leading. **Helipot Div, Beckman Instruments Inc, 2500 Harbor Blvd, Fullerton, Calif.**

Circle 330 on Reader Service Card

Trimmer potentiometer . . .

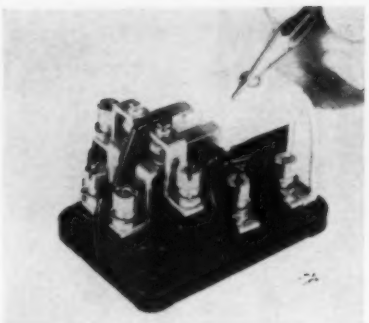
with 25-turn lead screw and clutch stops, uses a contact mechanism with long spring arms for ample spring range and uniform contact pressure over entire element. Designed for commercial printed circuit board applications requiring stable resistance element but not full military specifications. Resistance element performance equals or exceeds MIL-R-94B characteristic Y and provides infinite resolution. Power rating is 0.2 w at 158 F, with max operation up to 257 F. Resistance range is 500 ohms through 1 megohm (linear taper). Has diallyl phthalate molded frame and Delrin drive block, which are said to provide excellent electrical characteristics under high temperature and humidity. Case measures $1\frac{1}{4}$ x $\frac{47}{64}$ x $\frac{21}{64}$ in. Priced at $1.63 to $1.85 each in quantities of 500 and over. Delivery in 2 to 3 wk on quantities up to 100 and in 4 to 5 wk on larger quantities. **CTS Corp, Elkhart, Ind.**

Circle 331 on Reader Service Card

Spade and ring terminals . . .

are available in chain form to accommodate insulation range of from 0.035 to 0.110 in. and wire range from 20 to 27. Brass or tinned brass terminals come in three crimps: with insulation support; without insulation support; or with insulation pierce crimp. **Malco Mfg Co, Dept PE-1, 4025 W Lake St, Chicago 24.**

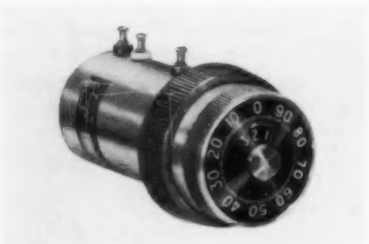
Circle 332 on Reader Service Card



Multipole relays . . .

are magnetically operated units available in 2-, 3- or 4PDT forms. Can be equipped with coils for ac operation to 230 v max and dc to 115 v max. Self-aligning, self-cleaning contacts are rated at 10 amp. Single unit measures $2\frac{5}{8}$ x $3\frac{1}{8}$ x $1\frac{53}{64}$ in. **Ward Leonard Electric Co, Mt Vernon, NY.**

Circle 333 on Reader Service Card



Concentric-scale microdial . . .

measures only 1 in. in dia, or $1\frac{5}{32}$ in. with addition of a fingertip brake. Projects $\frac{1}{8}$ in. from a panel and can be grouped as closely as $1\frac{1}{4}$ in. centers. Suitable for angular positioning of any precision potentiometer or shaft-controlled device of 10 turns or less, unit accommodates shafts of either $\frac{1}{8}$ or $\frac{1}{4}$ in. Available with choice of five brake knob colors and three combinations of numeral and background colors. Also offered with fluorescent numerals. **Borg Equipment Div, Amphenol-Borg Electronics Corp, 120 S Main St, Janesville, Wis.**

Circle 334 on Reader Service Card

Liquid filter . . .

consists of splashproof motor, directly connected to a 35-gpm centrifugal pump with oversize debris strainer on the inlet. Tank contains extended surface-type throwaway filter element capable of removing particles of down to 5 microns. Special elements are available for removal of even smaller particles. **Hilliard Corp, Elmira, NY.**

Circle 335 on Reader Service Card

Mechanical commutating switch . . .

is available in one-pole and multipole configurations for commutation of 64 and 100 channels of information. Designed for 20 cycles per sec operation, it is supplied with or without 1200-rpm, 115-v ac, 60-c synchronous hysteresis drive motor. Jet of mercury replaces conventional wiper arms for commutation, said to result in no wearing of parts and low maintenance. After commutating signals for over 1000 hr, unit can be restored to near original condition by cleaning switch parts and replacing mercury. From stock as of this month. **Advanced Technology Laboratories Div, American-Standard Corp, Dept AEI, 369 Whisman Rd, Mountain View, Calif.**

Circle 336 on Reader Service Card

Thermocouple assembly . . .

has swaged adaptor to hold extension leads securely to sensing probe. Swaged construction permits unit's use in temperatures up to 1500 F or to limits of various insulation on extension wires. Flexible stainless steel covering protects extension wires under rough service. Temperature probes using swaged adaptor are available in all calibrations. **Hy-Cal Engineering, 12105 Los Nietos Rd, Santa Fe Springs, Calif.**

Circle 337 on Reader Service Card

Torque table . . .

measures case reaction of test unit by means of bonded strain gages on special flexture straps that eliminate friction error sources (such as bearings and linkages). Since no slip rings are used, there is said to be no limitation to speed of rotation and no maintenance of bearings or brushes. Models are available in

continued on page 76

RBW FASTENER BRIEFS

RUSSELL, BURDSALL & WARD BOLT AND NUT COMPANY

Technical-ities

By Fred E. Graves

Fastening of rigid joints

Theoretically, there's no such thing as a rigid joint. There's always some elasticity of the fastened metals. For practical purposes, you can consider a joint rigid when the bearing areas of the metal-to-metal fastened members will not crush or yield before the full load-carrying capacity of screw or bolt is developed.

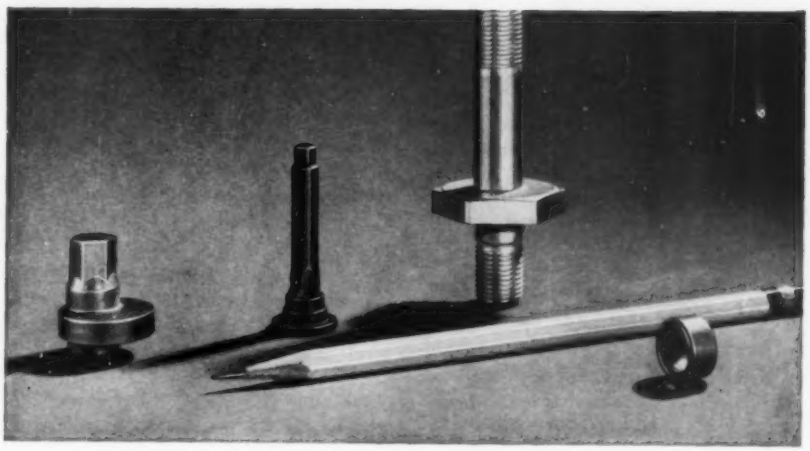
PRODUCT BENEFITS

Rigid joints afford a definite product advantage. They can take high strength hex screws or bolts tightened up to fastener yield strength or beyond. Under such tension, fasteners have demonstrated that they'll stay tight despite vibration. They are resistant to fatigue from the constant load reversals. High Strength Hex Screws cut costs and speed assembly too, since you can reduce *size* of the fasteners or their *number*, while actually improving joint strength.

INSTALLATION HINTS

When you're connecting steel members of fairly heavy section, you've no problem getting a rigid joint. Just clamp them to the full fastener capacity. Thin sections can be reinforced and similarly fastened. And in joining milder steels or softer metals, use of a plate washer will distribute bolt load, prevent crushing and give the desired effect of rigidity.

When to plan on cold-formed special parts



COLD forming is basically a large volume, low cost method of obtaining component parts.

Above you see four specific *types* of parts that benefit from this production method:

ECCENTRIC SHAPES

When the piece is radically eccentric, and is further complicated by having several different diameters, cold forming may prove the only way to produce the piece at a reasonable cost. Machining it from a bar would be prohibitive in scrap loss and machining time.

MULTI-DIMENSIONAL DESIGNS

When pieces are complicated, cold formers can often shape item in two or three blows. Tolerances are close enough for practical uses, and no further finishing need be done except for some secondary machining or drilling if required by the design.

ONE-PIECE PARTS

When simple, small two- or three-piece assemblies can be replaced with unit parts, the production man saves assembly time as well as material costs; the designer gets a stronger part. For example: stud with integral hex, square, or round upset anywhere in-between. Note the extreme upset shown.

PARTS WITH HOLES

Nut formers produce parts by the thousands per hour like the one shown above. Holes are punched out, leaving smooth, clean, work-hardened and strengthened surfaces.

Bear in mind that unlike machining, cold forming cuts none of the metal's flow lines. So parts are tougher and more fatigue-resistant, as well as more economical.

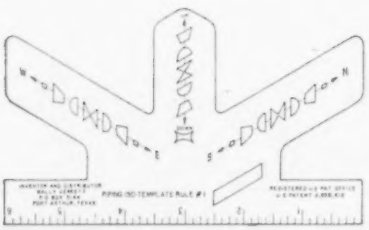
As a fastener manufacturer, RB&W makes an ideal and experienced source of supply for such items. The same facilities used for standard screws and nuts can also pound out the required specials. Refer your problem to Russell, Burdsall & Ward Bolt and Nut Co., Port Chester, N. Y.

Plants at: Port Chester, N. Y.; Coraopolis, Pa.; Rock Falls, Ill.; Los Angeles, Calif. **Sales office and warehouse at:** San Francisco, Calif. **Additional sales offices at:** Ardmore (Phila.), Pa.; Pittsburgh; Detroit; Chicago; Dallas.

CIRCLE 75 ON READER SERVICE CARD 75

ranges from 50 in.-oz to thousands of in.-lb for torque sensing when testing electric and stepping motors, generators, clutches and brakes, bearings, potentiometers or any other rotating device. **Lebow Associates, 14857 W Eleven Mile Rd, Oak Park 37, Mich.**

Circle 338 on Reader Service Card

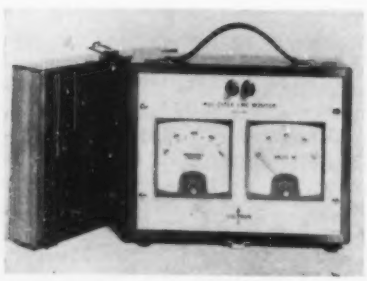


Isometric piping templet . . . enables standardized isometric drawings to be made of all pipe layout sketches. Pocket-size, laminated clear plastic instrument has cut-outs for most common fitting symbols, rounded corners for uniform angles and compass orientation points. Priced at $2.50 each; two for $4.75. **Wally Verrett, Dept 200, PO Box 3144, Port Arthur, Tex.**

Circle 339 on Reader Service Card

Vibration generators . . . and shaker units for analyzing effects of vibration on components and sub-assemblies, simulate these effects under varying service conditions. Six British-made models are available, producing peak thrusts of from 2 to 18,000 lb. **Rockbar Corp, 650 Halstead Ave, Mamaroneck, NY.**

Circle 340 on Reader Service Card



400-cycle line monitor . . . has two expanded scale meters, one to measure frequency and the other voltage, with an accuracy of 0.05% for the frequency meter and 0.5% for the voltmeter. Carrying case permits any combination of meters up to four. Priced at $375, with delivery in 30 days. **Voltron Products Inc, 1020 S Arroyo Pkwy, Pasadena, Calif.**

Circle 341 on Reader Service Card

DESIGN LITERATURE

Adaptive Control Systems

ELI MISHKIN & LUDWIG BRAUN JR. McGraw-Hill Book Co Inc, 330 W 42nd St, NY 36. 6 x 9¼, 533 pp. $16.50.

The universal example of adaptive control—a form of feedback control—is the human being steering an automobile. The driver continually injects small variational signals on the steering wheel in order to maintain the "feel of the road and car"; i.e., the driver is continually measuring the dynamics of the process to be controlled in order that he may be prepared to effect near-optimum control when input signals arise (when the eye detects a curve in the road, for example). This book—an outgrowth of a series of lectures at Polytechnic Institute of Brooklyn—is on industrial feedback controls, and covers the classic and practical aspects such as linear and nonlinear systems, dynamics, stability, computer-controlled systems, digital techniques, queueing, and multistage decisions. Graduate-level understanding is required.

The Role of Viscosity in Lubrication

OSCAR C BRIDGEMAN. American Society of Mechanical Engineers, 29 W 39th St, NY 18. 8¾ x 11, 107 pp.

The material includes proceedings of an ASME Symposium held March 10-11, 1958, sponsored by the Lubrication Division. Topics include: effect of temperature, pressure and rate of shear on viscosity; sensitivity of equipment and machines to variation in lubricant viscosity; lubrication of roll-neck bearings and gear drives; effect of viscosity on hydraulic systems; design criteria for selecting viscosity; gear lubrication and viscosity; recent research and development work in rolling bearings; effect of temperature and pressure on viscosity as related to hydrodynamic lubrication.

Other Books of Interest

Mathematics and Computers

G R Stibitz, J A Larrivee. McGraw-Hill Book Co Inc, 330 W 42nd St, NY 36. 5¼ x 8, 228 pp. $2.25.

Discusses relationship between pure and applied mathematics and automatic computers.

Energy in the American Economy 1850-1975

S H Schurr, B C Netschert. Johns Hopkins Press, Homewood, Baltimore 18. 6¾ x 10, 774 pp. $12.50.

An economic study of the history of the development of energy sources in the US, probable future energy needs, prospects for new developments.

A Treatise on The Calculus of Finite Differences

G Boole. Dover Publications Inc, 180 Varick St, NY 14. 5¼ x 8, 336 pp. $1.85.

Unaltered paperback edition of second and last revised edition published in 1872.

ABSTRACTS FROM THE LITERATURE

Electrostatic Angle Measuring

Describes an angle measuring system based on a composite fine and coarse electrostatic transducer and associated electronic circuitry, capable of digital measurement of shaft position to system accuracy of 400,000 (3.24 sec of arc).

"A High Accuracy Electrostatic Angle Measuring System," Jerome Machlis, Telecomputing Corp. AIEE paper 61-199. American Institute of Electrical Engineers, 33 W 39th St, New York 18.

Reinforced Plastics

Some of the characteristics and properties of reinforced plastics are reviewed and some new observations made. Use of hollow glass fiber reinforcements are proposed to reduce density and off-round filaments are suggested to increase strength in direction transverse to fiber axes.

"New Directions for Structural Reinforced Plastics," Gruntfest and Dow, General Electric Co. ARS paper 1579-60. American Rocket Society, 500 Fifth Ave, New York 36.

Boundary to Mixed Friction

Presents results of investigation that determined how various factors influence surface velocity at which transition from boundary to mixed friction occurs. Effects of additive concentration, viscosity, surface finish, load are discussed.

"The Transition from Boundary to Mixed Friction," R. L. Lenning, Cincinnati. Journal of American Society of Lubrication Engineers, Dec, '60. American Society of Lubrication Engineers, 5 N Wabash Ave, Chicago 2.

continued on page 79

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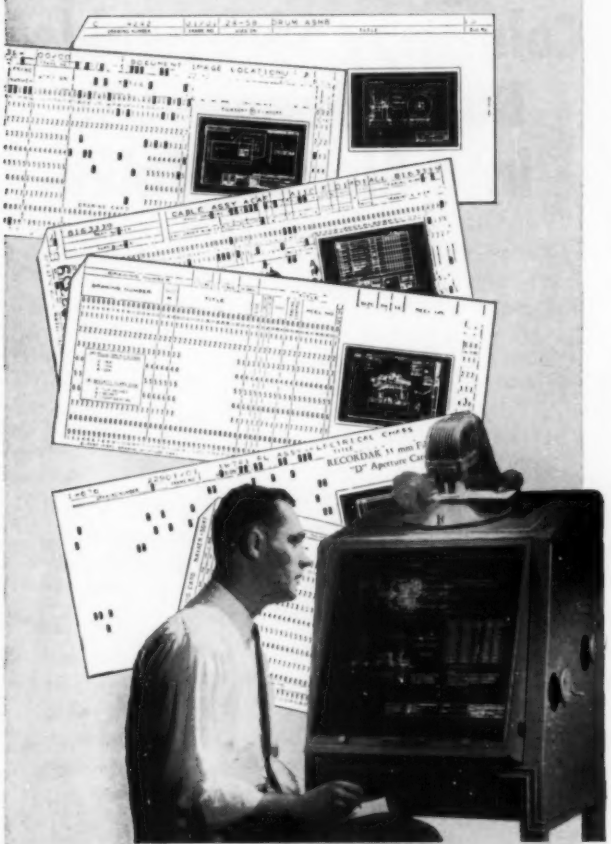

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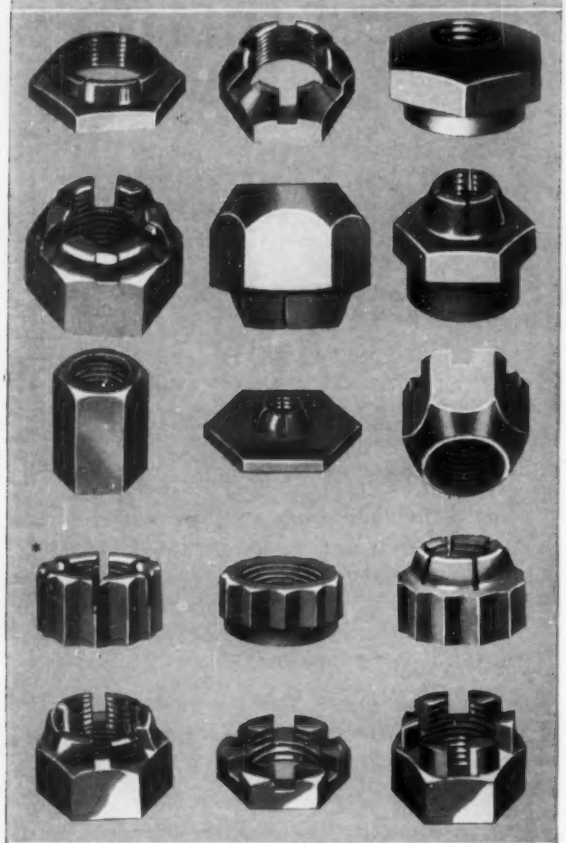

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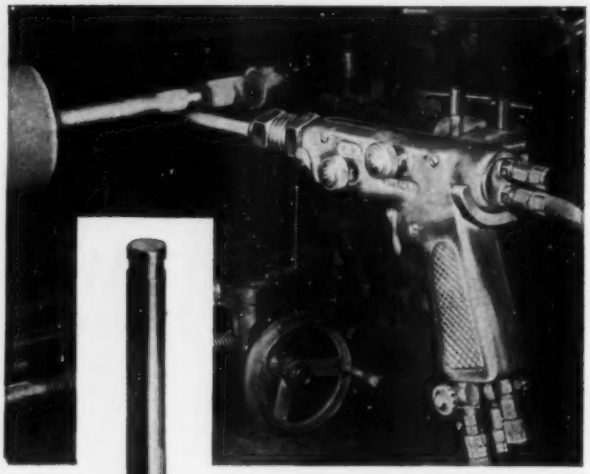

Above: A valve, with its ends protected by masks, receives a sprayed overlay of Colmonoy No. 6 hard-surfacing alloy. Left: A finished valve with long-wearing Colmonoy alloy stem surface.

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"Relay Stability," by Cameron, Lingelbach, and Feeny, Oklahoma State University. Published in NARM Relay Symposium Papers at 8th Annual Relay Symposium at Stillwater, Okla.

CATALOGS AND BULLETINS

To obtain copies of literature described below, circle corresponding number on postcard inside back cover.

CORROSION-RESISTANT METALS—Catalog, 18 pp. Contains application tables for martensitic, ferritic and austentic stainless steels; extra-low carbon, chromium-nickel stainless steels; copper-base, high-nickel alloy; and special nongalling alloys. Data on latter two includes chemical, mechanical and physical properties. Also lists over 200 product categories (along with special conditions existing during their manufacture) and gives the recommended metal to be used in processing equipment for each. Waukesha Foundry Co, Dept C-1, Waukesha, Wis.

Circle 350 on Reader Service Card

CONTROL KNOBS—Slidcrule and 22 x 34-in. wall chart. Both carry dimensional data for selection of more than 345 styles, including round and dial, pointer, crank and bar-pointer types. Also relate all dimensions to scale drawings of knob styles. Raytheon Co, Distributor Products Div, 411 Providence Highwy, Westwood, Mass.

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HIGH-TORQUE SETSCREWS—Bulletin 2067, 8 pp. Discusses axial, torsional and vibrational holding powers of properly tightened setscrews and relates these to factors that make for high allowable installation torques—including socket depth and configuration, precision rolling of threads, controlled heat treatment and proper tightening keys. Illustrations include microphotographs of grain structures and a torque–angular-displacement curve. Standard Pressed Steel Co, Box 545, Jenkintown, Penna.

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REINFORCED PLASTICS—Booklet, 8 pp. Presents processing advantages of preimpregnated reinforced plastics and laminating materials; case studies; and tables on

continued on page 80

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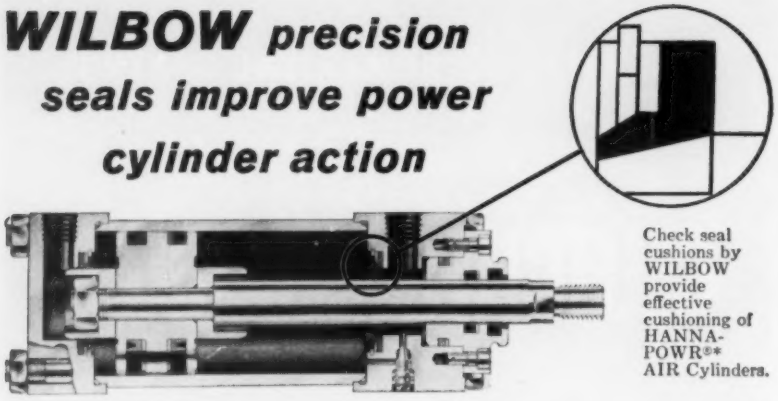

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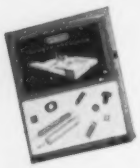

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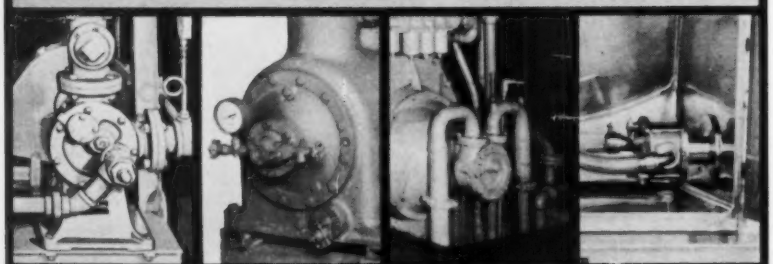

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available resin-reinforcement combinations, their characteristics and applications. Prepreg Div, Society of the Plastics Industry Inc, 250 Park Ave, New York 17.

Circle 353 on Reader Service Card

FLARED TUBE FITTINGS—Catalog K-690, 18 pp. Covers recommended pressures, wall thicknesses, temperature ranges, recommended flaring procedures, etc. of stainless steel fittings with fully confined Teflon seals. Tabulates dimensions and illustrates such fittings as gasket connectors, tees, elbows, unions, nuts and seats. Special Screw Products Co, PO Box 391, 100 Northfield Rd, Bedford, Ohio.

Circle 354 on Reader Service Card

CLAMP ASSEMBLIES, FIXTURE COMPONENTS—Catalog JF-61, 12 pp. Contains dimensional data and drawings representing more than 1000 items, such as single and double cam assemblies, hook clamps, eye and swing bolts, keys, nuts, spring plungers, screws, studs and washers. Accurate Bushing Co, 443 North Ave, Garwood, NJ.

Circle 355 on Reader Service Card

SILVER BRAZING ALLOYS—Brochure ADC 847C, 24 pp. Discusses brazing procedures, problems and solutions. Outlines properties of alloys, ranging from standard rod forms to one which incorporates a fluxing agent in the center of the wire, and provides tables for selection of proper alloy to meet particular needs. Air Reduction Sales Co, Div of Air Reduction Co, Inc, 150 E 42nd St, New York 36.

Circle 356 on Reader Service Card

MINIATURE BALL BEARINGS—Catalog 4E, 4 pp. Supplies dimensional data on inch, metric, pivot and special series ball bearings. Also lists part numbers of interchangeable inch series bearings produced by other manufacturers. Landis & Gyr Inc, 45 W 45th St, New York 36.

Circle 357 on Reader Service Card

MINIATURE FLEXIBLE COUPLINGS—Catalog 40, 4 pp. Outlines dimension, weight, torque and flex data on set screw-hub and clamp-hub types. Plots show lateral and torsional deflection. Naugler Engineering Inc, 19 Madison Ave, Beverly, Mass.

Circle 358 on Reader Service Card

ALUMINUM FORGINGS—Brochure, 20 pp. Reviews production of all types, including precision, conventional, no-draft, blocker-type, hand, smith and impact, as well as rolled rings and forged fittings. Mechanical properties of die forgings are tabulated. Harvey Aluminum, 19200 S Western Ave, Torrance, Calif.

Circle 359 on Reader Service Card

ADAPTER FITTINGS—Catalog 4360, 16 pp. Tabulates dimensions and working pressures of pipe- and straight-thread adapters for tubing system connections. Assembly instructions for straight-thread adapters with O-rings and metal seals are sketched. Parker Fittings & Hose Div, Parker-Hannifin Corp, 17325 Euclid Ave, Cleveland 12.

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ALTITUDE PRESSURES, DENSITIES—data sheets, 4 pp. Standard pressures (lb/in.^{2}) and densities (10^6 lb/ft^3) are given for each 100 ft of altitude from 0 to 100,000 ft. Also provide information on environmental sensing and switches associated with monitoring and control of pressure and density. Sales Dept, Newark Controls Co, 15 Ward St, Bloomfield, NJ.

Circle 361 on Reader Service Card

SOLENOID VALVES—Bulletin SL-1, 4 pp. Supplies data on size, pressure, temperature, coil type, special features and assemblies to aid proper selection of three types—piston-pilot, packless; direct acting; and semi-direct acting. Tabulates Cv flow factors for valve sizing. J D Gould Co, 4707 Massachusetts Ave, Indianapolis 18.

Circle 362 on Reader Service Card

MEASURING INSTRUMENTS—Condensed catalog A-26, 8 pp. Illustrates and traces specifications of impedance, capacitance and resistance measuring systems; resistance networks; and components, including impedance, capacitance and comparison bridges, decade transformers and voltage calibrators and dividers. Electro Scientific Industries, 7524 S W Macadam Ave, Portland 19, Ore.

Circle 363 on Reader Service Card

PILOT-OPERATED VALVES—Bulletin 91043, 4 pp., Covers operation, materials, sizes, pressures, dimensions, weights, etc. Includes cutaway, dimensional, and typical installation drawings. Airmatic Valve Inc, 7313 Associate Ave, Cleveland 9.

Circle 364 on Reader Service Card

SYNCHRONOUS MOTOR CONTROLS—Bulletin 3100-PRD-269, 2 pp. Describes, illustrates and gives specifications of units for motors rated 600 v and below. Electric Machinery Mfg Co, Minneapolis 13.

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BEARING BALLS—Booklet 494-IOM, 18 pp. Carries data on hardness, grades, tolerances, magnetic properties, etc. of $\frac{1}{32}$ to $2\frac{3}{8}$-in. balls made of chrome alloy steel, types 440 and 329 stainless steels; brass; aluminum bronze and silicon molybdenum steel. Sketches trace step-by-step manufacture of balls and measuring and testing methods. Hardness and grade con-

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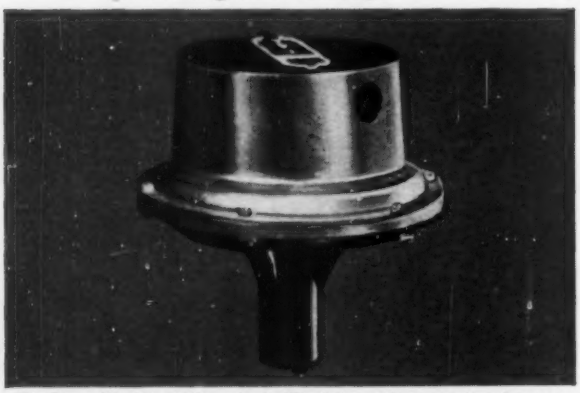

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DRAFTING-ROOM EQUIPMENT—Catalog ADR-612, 32 pp. Illustrates, describes design features, and gives specifications of full line of tables and files. Emphasis is put on planning layout that would reduce fatigue, increase draftsman efficiency and save floor space. Hamilton Mfg Co, Two Rivers, Wis.

Circle 367 on Reader Service Card

PRECISION WIRE—Bulletin, 4 pp. Details properties, characteristics and application of iron-chromium-aluminum alloy wire. Curves show temperature resistances, elongation vs wire diameter and breaking strength vs wire diameter. Molecu-Wire Corp, Eatontown-Freehold Pike, Scobeyville, NJ.

Circle 368 on Reader Service Card

ULTRA-PURE GRAPHITE—Bulletin, 8 pp. Reviews applications, purity limits, available sizes and physical properties (both molded and extruded forms). Graph shows variation of gas content for typical grades. Speer Carbon Co, St Marys, Penna.

Circle 369 on Reader Service Card

PRINTED CIRCUITS—Brochure, 8 pp. Depicts methods and facilities used in manufacturing printed circuit boards and subminiature precision parts. Gives sizes of "break" and conductive circuits made in both rolls and sheets. Komak Inc, 2632 W Cumberland St, Philadelphia 32.

Circle 370 on Reader Service Card

COPPER-BASE ALLOY FACILITIES—Booklet, 16 pp. Outlines physical properties of some 13 alloys and company's research and development, production control, plant facilities and finished products. Ampco Metal Inc, Milwaukee.

Circle 371 on Reader Service Card

PLASTICS FABRICATING—First issue, 1 pp. Technical case history series on fabricating vinyl and other flexible plastics. Polo Plastics Co, 1718 N First St, Milwaukee 12.

Circle 372 on Reader Service Card

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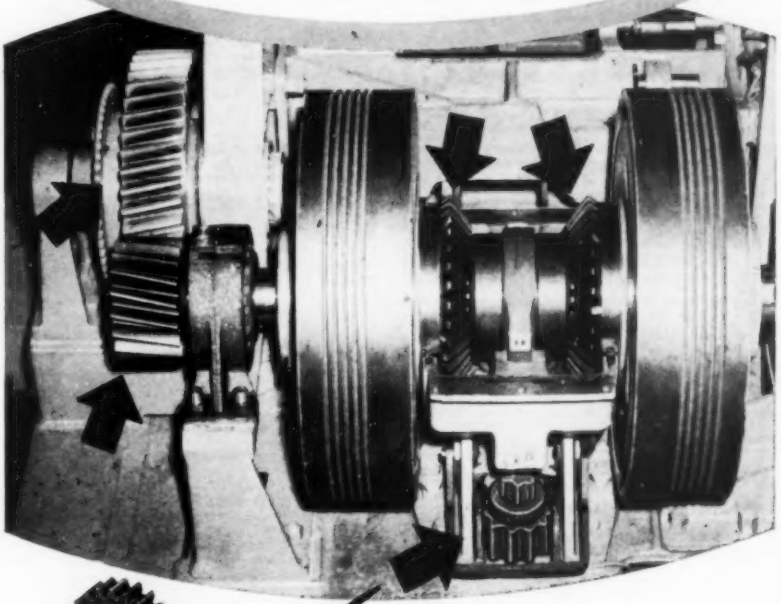

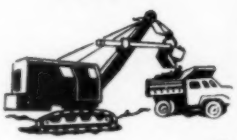

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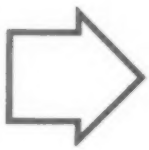

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The right choice of materials is certain when you bring your bearing problems to Bound Brook. Choosing from over 25 grades of sintered iron and bronze, our powder metallurgy engineers select the material with exactly the right properties for *your* application . . . the right balance of hardness, strength, ductility, density and thermal conductivity to fit your needs. They can create many special properties for you, too, by varying the composition of the metal powders. Your choice is always right when you choose Bound Brook for your bearings.

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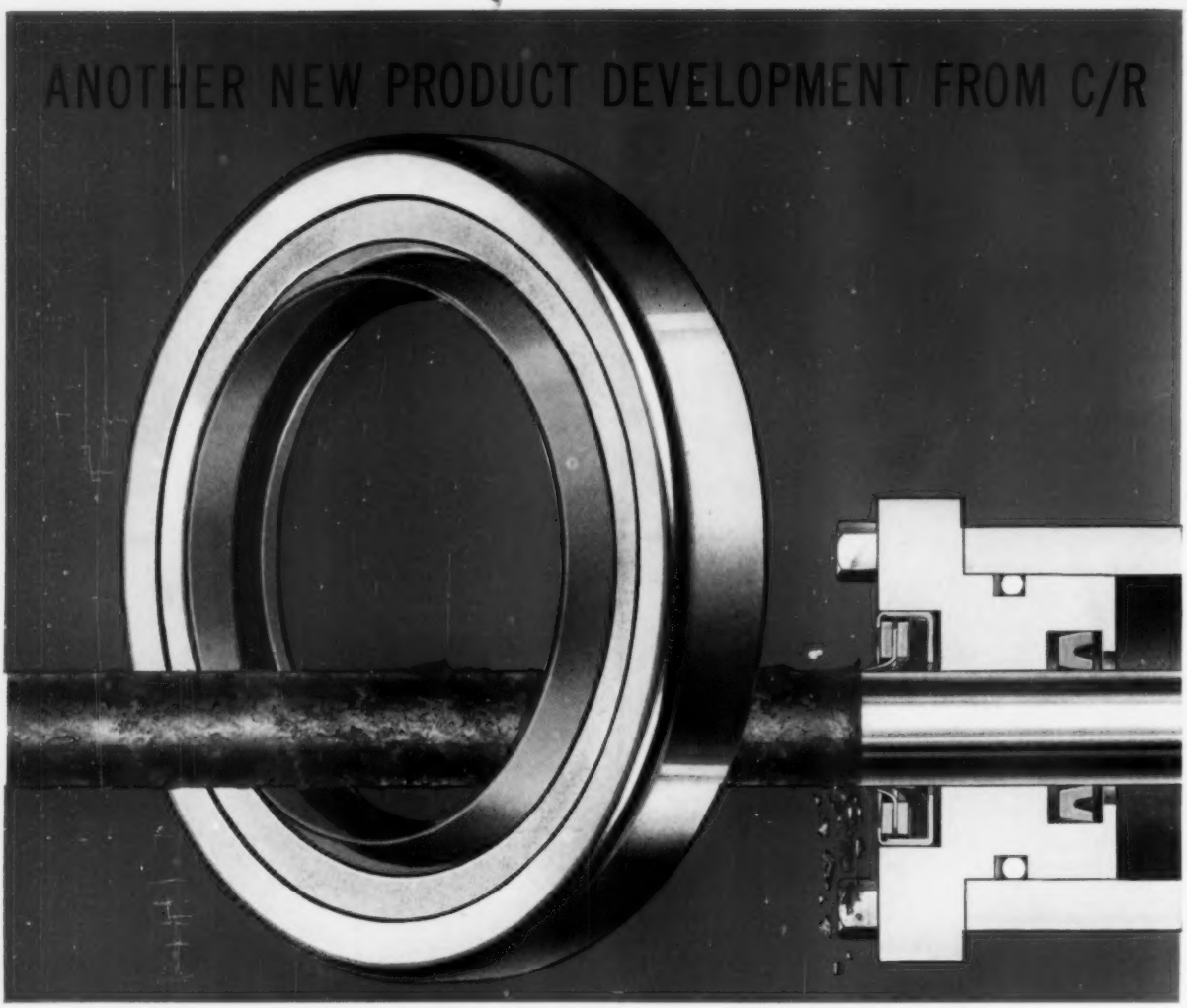

New Wiper-Scraper Seal for Cylinders

Scrapes off ice, mud, tar – wipes off water, dust, other contaminants

Now, you can effectively exclude dirt and other contaminants from hydraulic cylinders under the most severe field conditions. One compact unit, the C/R SC Wiper-Scraper Seal does the job. Formerly, a separate rod scraper had to be installed in front of the ordinary wiper seal. The special machining necessary, plus the scraper ring, and retaining ring made this an expensive installation.

Chicago Rawhide's SC Wiper-Scraper Seal combines a spring brass scraper and synthetic rubber wiping member in one steel shell. The I.D. of the scraper is slightly under shaft size to provide a snug fit that will remove tar or frozen mud, but it has sufficient play within the shell to tolerate any off-center conditions of the rod such as caused by bearing "bore-slop." The cost is much lower than any other combination of scraper and wiper. "Design-in" cost is low, assembly simple. Most important is the performance contribution to the cylinder. The additional value of longer packing life and increased operating dependability with the SC Wiper-Scraper Seal will far outweigh the nominal cost.

For complete information, specifications and standard sizes, write for your copy of C/R's new Bulletin SC-100

CHICAGO RAWHIDE MANUFACTURING COMPANY

OIL SEAL DIVISION: 1237 ELSTON AVENUE • CHICAGO 22, ILLINOIS
Offices in 55 principal cities. See your telephone book.
In Canada: Chicago Rawhide Mfg. Co. of Canada, Ltd., Brantford, Ontario
Export Sales: Geon International Corp., Great Neck, New York

C/R Products: C/R Shaft & End Face Seals • Sirvene (synthetic rubber) molded pliable parts
Sirvis-Conpor mechanical leather cups, packings, boots • C/R Non-metallic Gears.

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